NOLOGY DEPARTMENT

March 1948

TECHNOLOGY REVIEW

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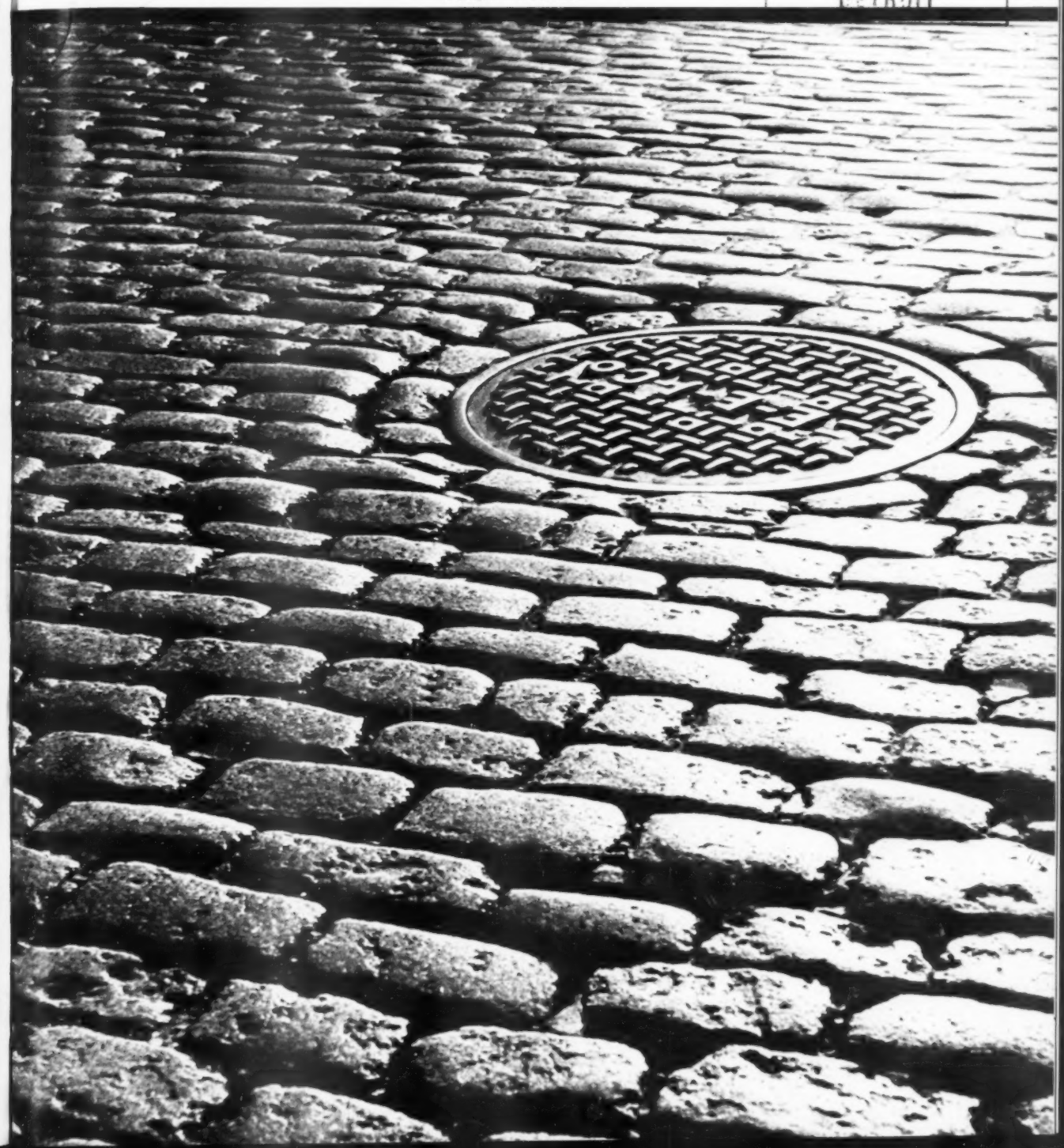

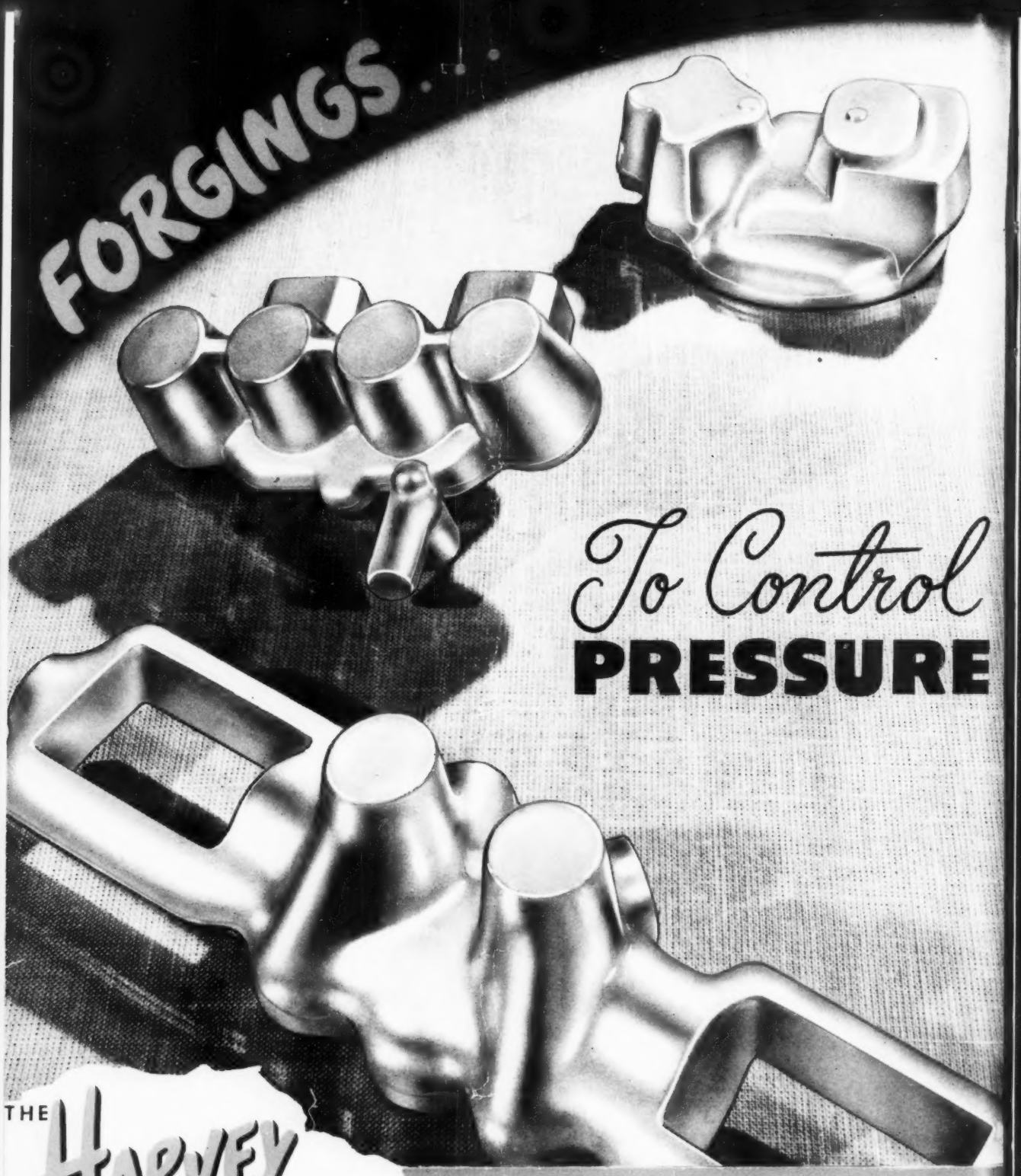

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FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOYS

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Unlike today's other rising costs which may be compensated for by larger volume, eye accidents are out-and-out embezzlers of your profits. THEY CUT BACK PRODUCTION—by putting "green" workers on the job, lowering shop morale, placing expensive equipment in less trained hands. All this, *in addition* to the direct cost of a major eye accident which some authorities estimate at $350 or more.
Good business judgment dictates that these costs be cut *immediately.* Your AO Safety Representative can show you how 98% of all eye accidents can be prevented by an eye protection program that will pay for itself in six months or less.

American Optical Company — *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, March, 1948. Newsstand Edition. Vol. L, No. 5. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

This tuning condenser, used in the famous National NC-2-40D, is a perfect example of National's flawless construction and design. Engineered and manufactured in National's own plant, it is of extremely rigid construction, preventing unwanted frequency modulation due to vibration. Three bearings on the rotor shaft assure permanent alignment. The drive is through a large preloaded gear. No strings to deteriorate, no backlash! Each rotor is individually insulated and has its own contact. Stator insulation is low-loss steatite.

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EST. 1914

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BAUXITE ore from mines like this is converted by Norton into one of industry's most useful products.

In unique, Norton-developed electric furnaces the bauxite is fused into aluminum oxide abrasive—known the world over by the trade-mark "ALUNDUM".

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designed for 5400 B/D operating at 6000 B/D

Lion Oil cat cracker accepted after 28 days initial run . . .

Typical of Lummus design, careful inspection, skilled construction and experienced operation is the performance of the catalytic cracker designed and built for Lion Oil Company, Eldorado, Arkansas.

This plant—the 31st Lummus catalytic cracking plant—went on stream September 16th. It not only met all guarantees but soon exceeded design capacity. It was accepted by Lion on October 13th after 28 days of continuous operation. On the 85th day of the initial run, the reactor was by-passed for the insertion of larger orifice plates to permit increased charge capacity. 6024 B/D of fresh gas oil charge have already been processed with a possible 7000 B/D in the near future—against a design capacity of 4500 B/D of fresh feed plus 900 B/D recycle. The unit has also exceeded the guaranteed percentage yield of high-octane gasoline and has produced 3070 barrels per day of 10 lb. RVP gasoline against a 2040 B/D guarantee.

Long initial runs have always been characteristic of Lummus plants. Among many outstanding initial runs is that of a Lummus catalytic cracking plant which ran 240 days before it was shut down for inspection.

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LUMMUS

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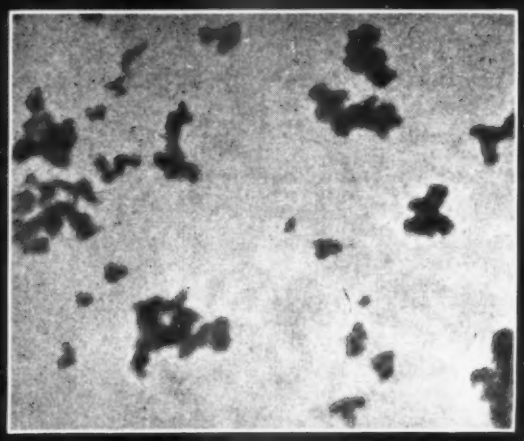
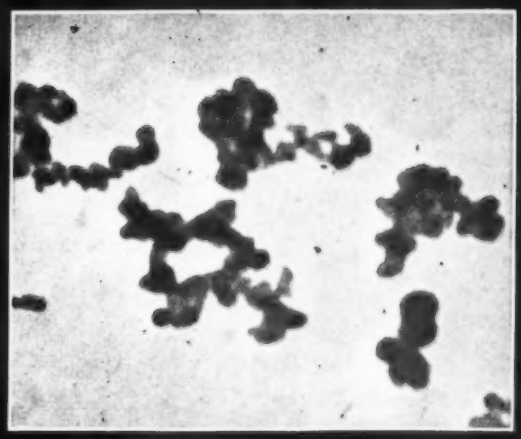
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas
LONDON—78 Mount Street, London, W. 1, England

Cabot Research and Development



Spheron 6. Magnification 59,000 times. Average particle size .0285 microns.



Sterling S. Magnification 59,000 times. Average particle size .06 microns.

Cabot Spheron 6 has added millions of miles of road wear to the nation's tire treads, while millions of pounds of Sterling S are consumed annually in the production of inner tubes, tire carcasses and mechanical goods.

Invisible under the ordinary microscope, individual particles of each are clearly revealed by the RCA Electron Microscope. Spheron 6 particles are less than .03 microns in diameter. Those of Sterling S nearly twice as large.

Particle size and properties in varied applications of carbon black are clearly related, making the RCA Electron Microscope an invaluable aid in predicting and controlling the properties of carbon black, a commodity essential to the rubber, paint, printing ink and many other industries.

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DESIGNS AND BUILDS COMPLETE PLANTS AND EQUIPMENT FOR THE PROCESS INDUSTRIES

For almost a half century, Vulcan has furnished the Process Industries with complete chemical processing plants and specially-engineered and fabricated equipment involving distillation, evaporation and extraction operations.

With this background of experience, the Vulcan organization effectively coordinates its complete pilot plant and laboratory facilities, competent engineering staff and modern plant equipment into rapidly evolving projects from initial conception into efficient processing plants.

Vulcan distillation evaporation extraction processes and equipment

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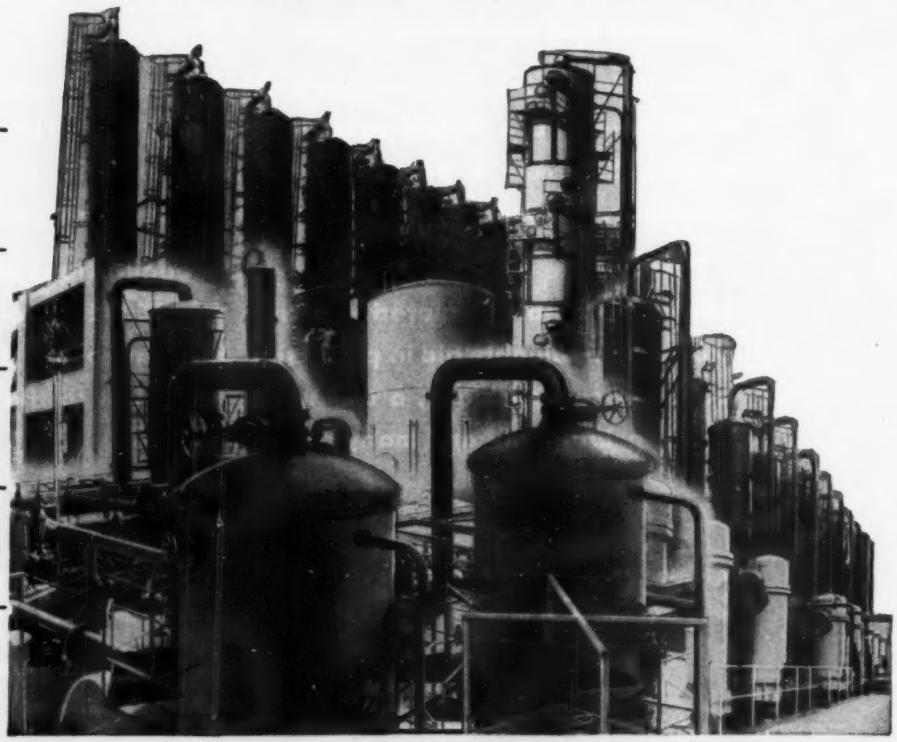
PROCESS DESIGN

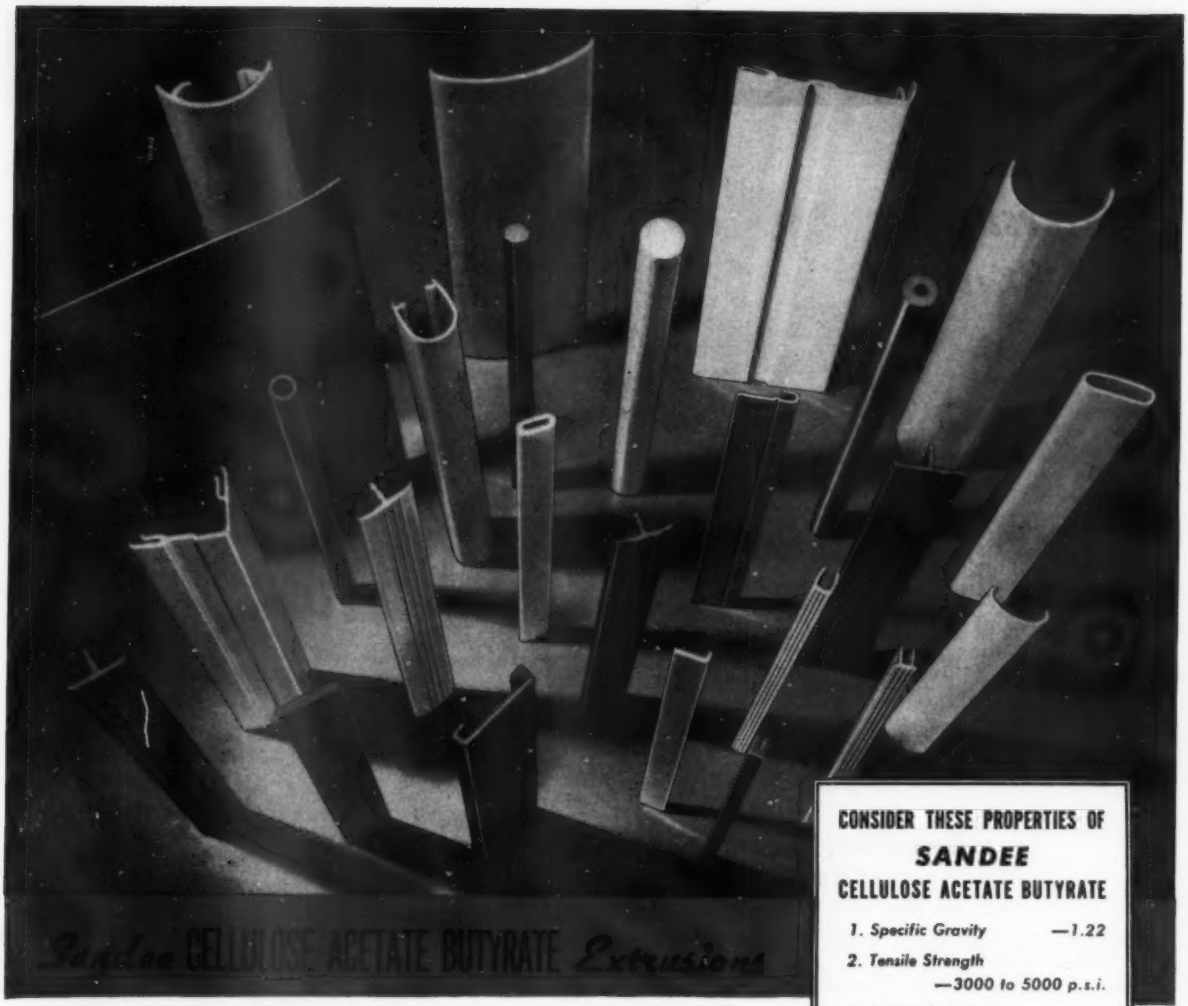
MECHANICAL DESIGN

SHOP FABRICATION

FIELD ERECTION

INITIAL OPERATION





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1. Specific Gravity	—1.22
2. Tensile Strength	—3000 to 5000 p.s.i.
3. Impact Resistance	—Excellent at normal temperatures
4. Heat distortion	—170° to 185°F.
5. Rigidity	—Good to very good
6. Dimensional Stability	—Good to very good
7. Water Absorption	—1 to 2%
8. Burning Rate	—Slow
9. Odor	—Nil to faint
10. Color	—Unlimited
11. Finish	—Excellent
12. Machinability	—Excellent

THIS general purpose material, under the trade name TENITE II, has attained an excellent reputation for appearance and serviceability in widely diversified fields. This is not only true in injection molded and fabricated items but is equally true in Extruded Rods, Tubes, and simple and complicated shapes. Colorful, tough, easily machined and easily formed to fit specific contours, it is serving to complete satisfaction in fields ranging from rods and tubes for toys to furniture and refrigerator trim.

Study the properties of this excellent general purpose material, then check with *Sandee* for confirmation of suitability to your requirements. *Sandee's* practical know-how in extrusion often helps in altering designs for improvements in functional utility, appearance, and cost.

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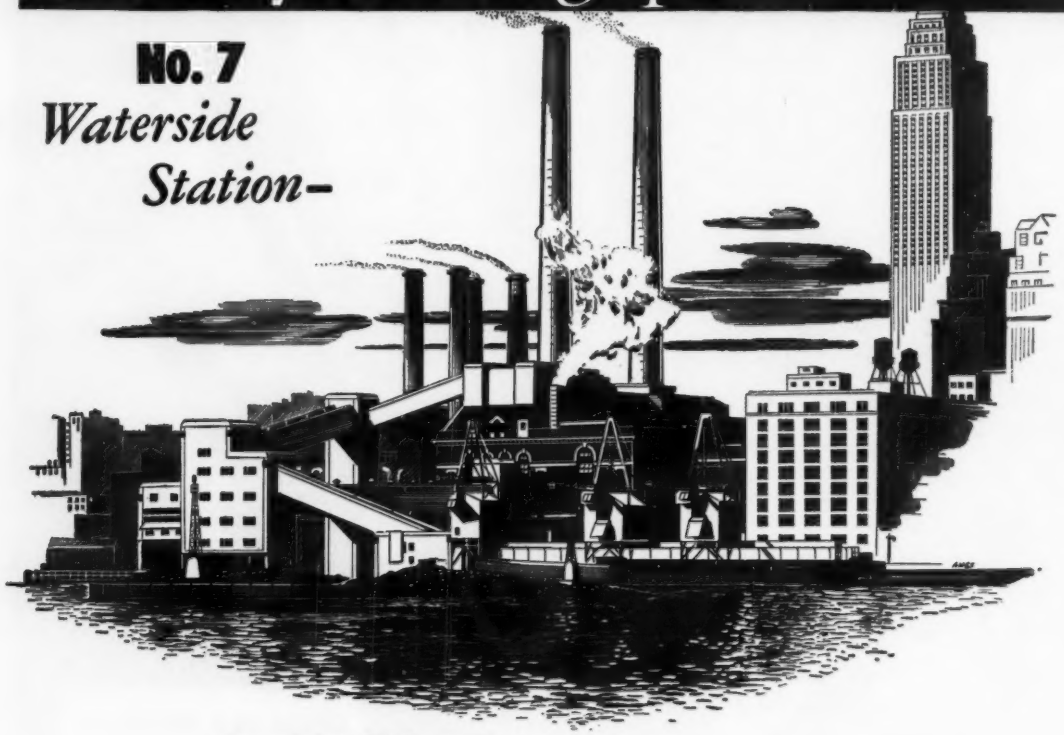
History-making power stations

No. 7
Waterside Station–



Consolidated Edison Company of New York, Inc.

PERHAPS no public utility station in America so perfectly parallels this century's progress in power generation as the Waterside Station of the Consolidated Edison Company of New York. Existing from about the turn of the century, this station has spanned virtually the whole development of power practice from small, hand-fired boilers and engine-driven generators to the giant, high-pressure boilers and turbines of the present day.

Although expanded and improved through the years, the real modernization program of the two plants comprising Waterside began in 1936, when work was started on the installation of *eight* huge boilers to replace the *ninety-two* old boilers in Plant 2. Modernization of Plant 1 is now well under way and the *two* boilers being installed will replace *fifty-three*. Extensive improvements with respect to turbines and other equipment have accompanied the boiler replacement program.

This is, without question, the greatest modernization project in the entire utility field . . . one of the world's largest power stations completely rebuilt . . . its capacity *nearly doubled* within the same building space . . . its economy vastly improved.

This policy of continuing modernization, characteristic of the electric utilities generally, is one of the big reasons why this industry is in the unique position of being able to sell its product today at a lower price than before the war. Electricity, long recognized as America's most valuable servant, continues to be America's *best buy*.

Combustion Engineering is proud of its major part in the Waterside modernization program. Eight of the ten high-pressure boilers replacing 145 old boilers are of C-E design and manufacture. Four of these units have capacities of 500,000 pounds of steam per hour, two of 615,000 pounds and two of 1,000,000 pounds.

COMBUSTION ENGINEERING

200 MADISON AVENUE • NEW YORK 16, N. Y.

The association of C-E with Waterside and many other power stations that have made history speaks for itself. The experience, special skills and advanced engineering that have brought about these associations are available to you, whether your steam requirements be large or small.

These three factors are the unwritten plus-values in every C-E contract –

Knowledge – *to solve today's, and tomorrow's, steam generating problems.*

Experience – *to interpret, from a world-wide background in every important industry, the specific needs of each installation.*

Facilities –*to manufacture complete steam generating units for every capacity from 1000 pounds of steam per hour up to the largest.* B-16

EXPERIENCE

Stone & Webster Engineering Corporation designed and constructed this Plant at Fort Wayne, Indiana, for the Defense Plant Corporation. It was operated during World War II by General Electric Company.

DESIGNED and built during the War, this plant, now owned by General Electric Company, is an example of what Stone & Webster Engineering Corporation offers clients in the industrial fields.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

REMOVE METAL *Fast*
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BROWN & SHARPE SIDE MILLS

STAGGERED TOOTH SIDE MILLING CUTTERS. Alternate right- and left-hand spiral angles with considerable angle of undercut permit these cutters to remove large amounts of metal without destructive vibration and chatter.

SIDE MILLING CUTTERS. Used in pairs for sizing nuts, bolt heads, similar work. Cutting edges on both sides of teeth and periphery.

HALF SIDE MILLING CUTTERS. Spiral on top and undercut on side give teeth improved cutting action.

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Hevi Duty Electric Co.
Surges Transformers

With the acquisition of the Surges Electric Company of Milwaukee, Hevi Duty can now offer quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements. An accelerated program of modernization will present opportunities for increased production and good delivery schedules.

Write for Bulletin S-4611

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

THE TABULAR VIEW

Industrial Patterns.— Under this title there appeared on page 209 of the February issue of The Review photographs of unnamed subjects of science, engineering, or industry. The identity of these pictures is given below:

1. *Top triangle:* Bolt Heads — by Henry M. Mayer.
2. *Left:* Steel Flooring — by Romeo Rolette.
3. *Right:* Sand Bags — by Juliette Laserre.
4. *Lower left:* Wall padding of acoustic dead room of the Bell Telephone Laboratories.
5. *Lower right:* Wooden Stakes — by K. Stephen.

Photograph Number 4 comes from Bell Telephone Laboratories; all others from Black Star.

Cross Continent.— Promontory Point, Utah, was the scene of jovial celebration on May 29, 1869, when the Union Pacific Railroad was joined with the Central Pacific Railroad to connect the West Coast with Omaha and Chicago in the first transcontinental railway system in this country. In "Road to Fortune" (page 260) E. H. CAMERON, '13, describes this famous railroad engineering venture of the post-Civil War period. Mr. Cameron has had extensive experience on many engineering projects throughout the country since his graduation from M.I.T. and is now head of the Technical Publications Division of Jackson and Moreland. As a hobby, Mr. Cameron, who is well known to Review readers, combines his engineering training and writing abilities in portraying the post-Civil War history of important engineering projects.

Diplomawise.— The Review is happy to be able to present (page 266) to its readers the commencement address which PRESIDENT COMPTON delivered to almost 400 former students who received their degrees and became Alumni on February 4. The Review also takes this opportunity to extend a hearty welcome to the Class of 2–48 as the latest group of loyal Alumni of M.I.T. Of course many of the Institute's recent graduating classes have had the pleasure and benefit of Dr. Compton's wisely prepared commencement addresses, but the Class of 2–48 could take justifiable pride in the knowledge that President Compton had added still another to his long list of well-deserved recognitions in having recently been made an honorary commander of the Order of the British Empire (page 271).

Left-Handed Sextants.— Had Hadley had the benefit of advice from psychologists it is not likely that he would have produced an instrument which, for two centuries, inflicted inconvenience on all but southpaw navigators. Such at least is the inference to be gleaned from "Psychology, Men, and Machines" (page 267) by COMMODORE W. MACK ANGAS, '17, who acquaints the reader with recent progress made in the Navy to improve the design and increase the effectiveness of control mechanisms for training and combat use. Almost invariably writing about one phase or another of nautical history, Commodore Angas has been a frequent contributor to The Review since 1940. His article reflects personal rather than official Navy views.

HOW MUCH COST CAN A SAW BLADE CUT?

Plenty—if it's made of molybdenum high-speed steel. Most of the major hacksaw blade manufacturers have standardized on molybdenum steels.

Why? Because molybdenum steels for saw blades are not only cheaper than 18-4-1, but they last much longer. Records made in the customer's plants have proved the wisdom of their choice.*

The same reasons—10¢ to 20¢ a pound saving over 18-4-1; more tools for the same gross weight of steel; better cutting performance; longer operation between regrinds—are back of the widespread adoption of molybdenum steels for all sorts of metal-working tools.

If you'll compare actual tool costs on any particular job, we think you'll discover why it pays to specify molybdenum high speed steels.

**Our booklet on molybdenum high speed steels will give you proof of these statements. Write for it.*

MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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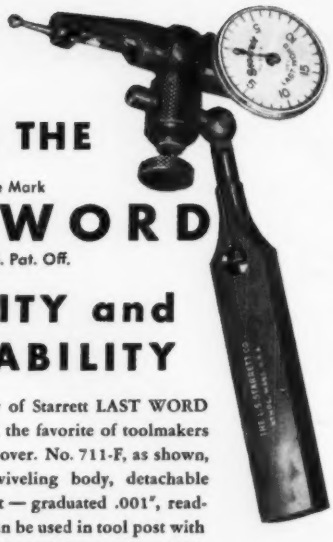

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in UTILITY and ADAPTABILITY

The universal adaptability of Starrett LAST WORD Indicators has made them the favorite of toolmakers and mechanics the world over. No. 711-F, as shown, has reversible action, swiveling body, detachable ratchet joint contact point — graduated .001", reading 0-15-0. range .030". Can be used in tool post with universal shank or clamped to height gage. Available in other models and calibrations.

For complete information, write for new Starrett Dial Indicator Catalog "L"

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WORLD'S GREATEST TOOLMAKERS

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PRECISION TOOLS • DIAL INDICATORS • STEEL TAPES • GROUND FLAT STOCK

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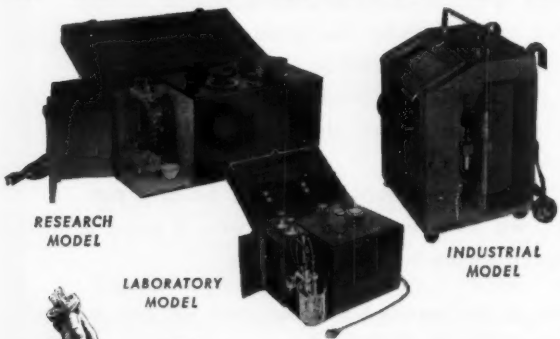
CAMBRIDGE



pH METERS

line-operated — accurate!

The three models illustrated above incorporate many new and important advantages. All are AC line-operated . . . no battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is a direct-reading instrument, ruggedly built for plant use.

Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Other line-operated Cambridge pH equipment includes single- and multi-point indicators and recorders. Send for bulletin 910-MR.

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3707 Grand Central Terminal, New York 17, N. Y.

Pioneer Manufacturers of

PRECISION INSTRUMENTS

MAIL RETURNS

Four Score and Ten

FROM WILLIAM HOVGAARD:

On the occasion of my 90th birthday I had the pleasure to receive about 100 letters of congratulation from former students of my Course in Naval Construction at M.I.T., given during the years 1902 to 1933.

I wish first to thank them most cordially for the praise and appreciation expressed in those letters, and I wish I could answer each of them individually. This, however, is impossible on account of my present low state of health and strength, and I must limit myself to reply by means of this more general letter. In addition I intend to send, and have in fact already commenced sending, a few individual letters to those who have written more special or personal letters to me.

I want to tell all of my former students that I have enjoyed my work as their teacher, not only as an important and interesting duty, but also as an honor and a pleasure. When I started work teaching at the beginning of 1902 I was nearly 46 years younger than I am now and I felt as if I was among younger comrades. This happy feeling of comradeship was reciprocated and made me feel at home. It has persisted in principle throughout the years and has been confirmed by many lifelong friendships and by the recent friendly letters of congratulations which I have received and treasure.

It gives me the highest satisfaction and the greatest possible reward to know from these letters that my work has been useful and successful and of service generally.

Summit, N. J.

Coincidence

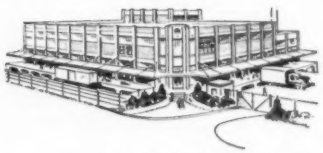
FROM FREDERIC W. NORDSIEK, '31:

On January 25, two weeks after my copy of the January issue of The Review arrived, the New York *Times* published a syndicated story dealing with calluses and burns. The news story thoroughly corroborated the statements in "Marked Men" on page 148 of the January issue. I thought you might be interested in what appears to be a somewhat unusual coincidence, especially since a certain similarity of wording in the two stories may have been evident to those who had read "Marked Men."

New York 23, N. Y.

[Mr. Nordsiek's Trend of Affairs piece was indeed the inspiration for the syndicated story which was used in a number of news broadcasts and printed in other newspapers as well. It is flattering to know that copy in The Review stimulates national coverage; the pleasure is doubled when the source of the material is also acknowledged. — Ed.]

Speed with Economy



U. S. Industrial Chemicals, Inc.

In our weekly "job meetings" each building operation comes up for examination in detail by our full staff, with complete minutes of each meeting sent to the owner. In this way, work is continuously planned ahead and coordinated.

W. J. BARNEY CORPORATION

101 PARK AVENUE, NEW YORK

INDUSTRIAL CONSTRUCTION

Alfred T. Glassett, '20, Vice President

"The outward forms the inward man reveals"—OLIVER WENDELL HOLMES

Why fabrics get better all the time

31 CHEMICALS helped make that shirt!

And those chemicals—plus many others—bring you brand-new fabrics of finest quality. They create new color effects and radiant "combination" tones and patterns in modern clothing . . . rugs . . . draperies . . . blankets. These better fabrics are made possible by *better materials.*

Chemically made fibers, for example, that challenge nature's best in wear and appearance. Better chemicals, too, in wetting agents . . . shrink-proofing treatments . . . solvents for dyes . . . and other "musts" that are a part of modern textile manufacturing.

Also in the picture are stainless steels for dyeing vats that are easy to clean and resistant to corrosive acids and alkalies. Plastics for bobbins, pins, levers, control handles and for many another tool part. And even such *new and better materials* as synthetic sapphire for the thousands of thread guides on huge textile machines.

Producing these better materials and many others—for the use of science and industry and the benefit of mankind —is the work of the people of UNION CARBIDE.

FREE: *You are invited to send for the illustrated booklet, "Products and Processes," which describes the ways in which industry uses UCC's Alloys, Carbons, Chemicals, Gases and Plastics.*

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AND CARBON CORPORATION
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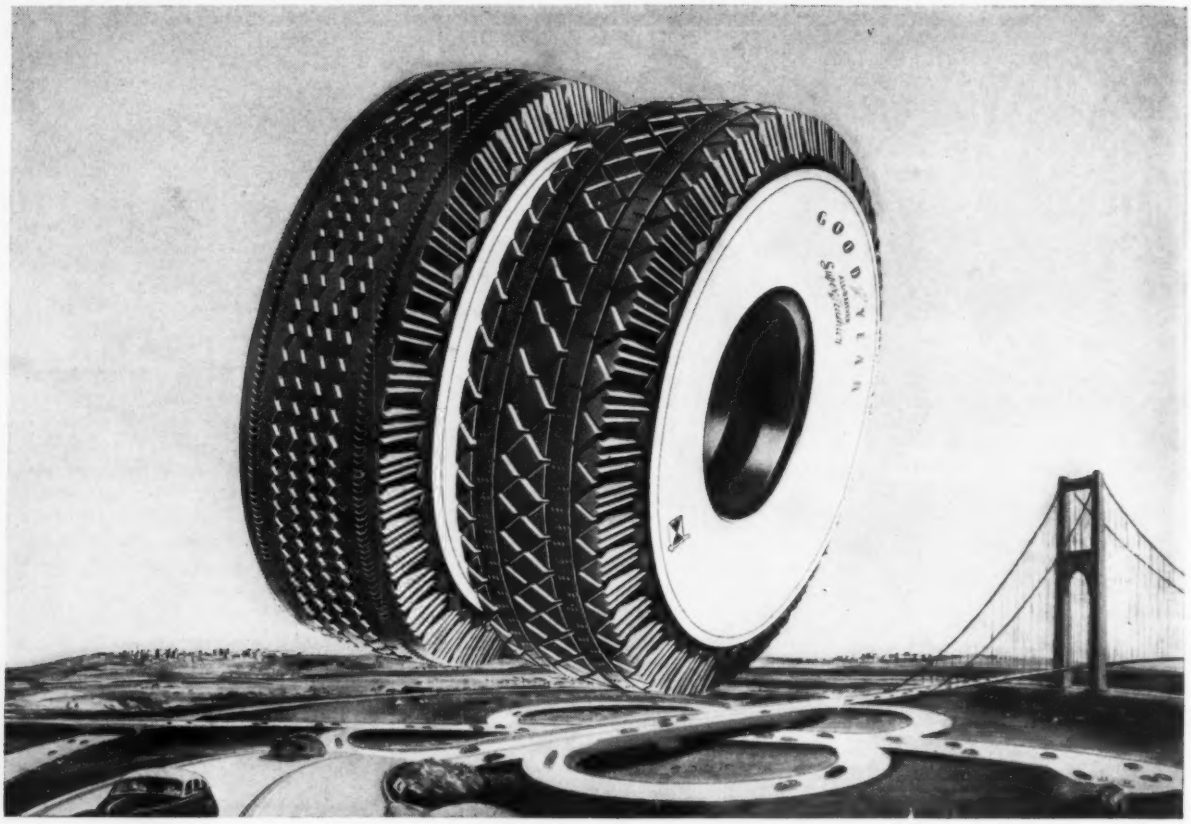

Amazing...what this new kind of tire will do for your car!

PICTURED ABOVE is the first new *kind* of tire in fifteen years! It's the great new Super-Cushion—developed by Goodyear. It runs on only 24 pounds of air—and offers all these advantages:

Softer Ride—Bigger and softer, the Super-Cushion gives you an unbelievably smoother ride!

Better Car Handling—Your car *hugs* the road, seems to *float* through traffic, to *flow* around turns!

Fewer Rattles—Super-Cushions *soak up* shock and vibration. You get fewer rattles, fewer repair bills!

Greater Mileage—Super-Cushions consistently average more mileage than the finest standard tires!

Extra Blowout Resistance — They "roll with the punch," are harder to cut, bruise, blow out!

Better Car Looks—Because they're bigger, Super-Cushions vastly improve your car's looks!

See Your Goodyear Dealer! If he hasn't Super-Cushions in your size at the moment, he will *soon!*

The new *Super Cushion*

by GOODYEAR

1898 GOODYEAR 50 1948

Super-Cushion T.M., The Goodyear Tire & Rubber Company

VOL. 50 No. 5

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

☆ ☆ ☆

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Raymond E. Hanson

Early Morning, Gloucester

THE
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The Trend of Affairs

Illusive Sweetness

CERTAIN substances other than sugars taste sweet. Saccharin (*o*-sulfobenzamide, $C_7H_5O_3NS$) is several hundred times sweeter than common cane or beet sugar, although the exact ratio of sweetness depends upon respective concentrations of solutions compared. Saccharin was first prepared in 1879. It has long been accepted as not toxic to human beings and, as it has no food value, has gained limited use to sweeten foods for persons on restricted diets, such as diabetics or those wishing to lose weight. Then saccharin tablets suddenly appeared upon many home dining tables during the wartime sugar shortages a few years ago, for use in place of the absent contents of the sugar bowl.

During the war years when sugar supplies were at their lowest ebb, it was proposed that products like carbonated beverages be sweetened with saccharin instead of with sugar. Such substitution was, however, forbidden by governmental food authorities, on the basis that consumers unconsciously associate sweet taste with food-energy value, since all normally sweet foods are high in sugar, and hence high in calories. Therefore a product that tastes sweet but has no caloric value was considered to be adulterated.

The wisdom of this ruling has now been confirmed by a research report from the University of Budapest just published in this country. This report shows that saccharin solutions taken by mouth lowered concentration of sugar in the blood stream of human subjects. Apparently this effect resulted from reflex stimulation of insulin secretion by the sweet taste of the saccharin. Insulin is the hormone, generated by the pancreas, that governs carbohydrate metabolism. The sweetness of sugar presumably has a similar effect, but when sugar is consumed the increased insulin production is offset by immediate availability of sugar through the digestive tract, with the result that the level of the sugar in the blood stream is not thus depressed.

Depression of blood sugar by saccharin is transient, and is not necessarily baleful. Nevertheless, the possibility of physiological maladjustments becomes apparent in the use of substances like saccharin that have the taste of a normal food but no food value. This is one immediate practical significance of the Hungarian report.

But even more striking is a theoretical implication of this research. By showing that the mere taste of a food triggers the physiological mechanisms necessary for its assimilation, this study underlines the extreme complexity of the interrelationships that govern the functioning of the human organism.

From Fossils to Seeds

IN February, 1946, Chinese explorers came upon a new and striking kind of fir tree in a remote valley of central China. Only three specimens were found, but later in 1946 a second expedition located 25 more trees, all metasequoias, a rare species that thrived 100,000,000 years ago, and long thought to be extinct, since it had been previously known only from fossil records. Only a few other trees now living are of such ancient origin, including California redwoods, and the ginkgo of China.

Although the discovery of living metasequoias was of unusual scientific value and interest, investigators discovered that so few specimens of the tree were living that it was in danger of extinction. To prevent the loss of a species which had been on earth long before man appeared, the Arnold Arboretum of Harvard University organized an expedition to secure seeds from the tree. After three months of field work, during which nearly 100 more metasequoias were located, the botanists secured an ample supply of seeds. These seeds which look much like rolled, dried corn kernels have now arrived at the Arboretum. Botanists will plant them in carefully selected soil and Elmer D. Merrill, Arnold Professor of Botany at Harvard, expects that 10 years of growth will produce a tree five or six feet in height. However, very little is

The world's first swept-wing bomber, the Boeing XB-47 Stratojet experimental jet bomber, made its maiden flight just 44 years to the day after man's first powered flight in a heavier-than-air machine off the sands of Kitty Hawk, N. C., and shortly before the death of pioneer aviator Orville Wright.

The radical new six-jet craft, whose design forecasts the shape of high-speed aircraft of the future, remained aloft 50½ minutes. It was piloted by Robert M. Robbins, '38, and Scott Osler, who expressed satisfaction with the plane's performance after its initial flight. Top speed of the new bomber was not announced but the Air Force revealed that the XB-47 was "in the 500 mph class," that it was designed to carry more than 10 tons of bombs, and has a design gross weight of 125,000 pounds. Span of the XB-47 is 116 feet, and length 108 feet. The tail reaches a height of 28 feet from the ground. The landing gear consists of two double-wheel units which fold forward into fore and aft sections of the slim fuselage. Small outrigger wheels, which retract into the inboard power plant nacelles, provide lateral stability during ground operations. Power is developed by six turbo-jet engines capable of exerting a total of 24,000 pounds of thrust, plus 18 Aerojet jet-assisted take-off rocket motors, each of 1,000 pounds thrust. Total thrust, therefore, is 42,000 pounds.

known of their growth patterns; it is not even certain that the seeds will germinate in New England climate. To overcome climate difficulties the Arboretum is sending seeds to gardens throughout the United States and Great Britain in the hope of finding the best growing conditions for the Chinese tree.

As it grows in China, the metasequoia is a large tree, usually growing more than 100 feet high and with a trunk of seven and a half feet in diameter. Although a cone-bearing tree, it loses its leaves in the winter months. Botanists compare its appearance to the swamp cypress which grows in the southern sections of the United States.

Like the sequoias of the West Coast, this species can scarcely be distinguished from the fossil forms of prehistoric times, and thus it presents one of the best examples of the persistence of life forms through many millions of years.

Cold Air

SOUND waves can be used to measure upper atmosphere temperatures stated Everett F. Cox of the Naval Ordnance Laboratory at a joint meeting of the American Physical Society and the Institute of Aeronautical Sciences at Columbia University.

Around a source of loud noise, such as the explosion of an ammunition dump, there are alternate rings of noise and silence, Dr. Cox said. No noise may be heard at one place and a few miles farther away windows may be shattered by sound waves. This condition is caused by layers of hot air in the upper atmosphere which serve as sound reflectors.

Since sound waves are bent back to the earth by the hot layers of the upper atmosphere, measurements of sounds received at great distances from explosions can be used to calculate temperatures of the earth's outer air layers. From observations of large-scale explosion such as that at Helgoland last year, the earth's atmosphere has been found to be divided into three layers of widely different temperatures. The first layer of air above the earth, extending 8 to 20 miles, averages about 75 degrees F. below zero. The next, containing a high proportion of ozone which absorbs ultra-violet rays from sunlight which heats it, averages about 100 degrees above zero. Beyond this is another layer of colder air, and at still higher altitudes the temperature again rises.

The research is important in supersonic flight problems.

Contributions to Physics

INDICATIONS of the Institute's position in the field of modern physics may be gleaned from the program of the annual meeting of the American Physical Society which was held at Columbia University from January 29 to 31. With 218 scientific papers scheduled for presentation, close to the record, 26 papers (or 11.9 per cent of the total number) were presented by members of M.I.T.'s teaching and research staff. Such participation does not include meetings at which Faculty members presided, nor does it include papers presented by Alumni who are not now on the staff at M.I.T. The figures quoted above, therefore, serve as a guide to the extent in which the Institute shares in the development of physics in the United States.

Invited papers were presented by Professor Hsue-Shen Tsien, '36, who spoke on "Wind Tunnel Testing Problem in Super-Aerodynamics"; by Professor Wayne B. Nottingham who outlined "The M.I.T. Electron-Physics Programme: Past, Present and Near Future"; and by William P. Allis, '23, Associate Professor of Physics, who discussed "Electrical Phenomena in Gases at Microwave Frequencies."

Papers in the more highly theoretical fields enumerated below were delivered by: Sanborn C. Brown, 10–44, and Martin Deutsch, '37, on cosmic rays and counters; D. Q.

Posin, Melvin A. Herlin, and Sanborn C. Brown on electron physics; Arthur F. Kip, Robert D. Arnold, 2–44, and Herbert B. Callen, '47, on magnetism and nuclear resonance; Malcolm W. P. Strandberg, Tunis J. Wentink, and Richard E. Hillger on optics; George E. Valley, Jr., '35, John M. Blatt, Robert W. Williams, 2–46, and Robert I. Hulsizer, Jr., '09, on cosmic rays; Arthur R. von Hippel on the solid state semiconductors; Bernd T. Matthias, Arthur R. von Hippel, James W. Davisson, '43, and Robert G. Breckenridge, '42, on solid state and ionic crystals; Clark Goodman, '40, Edward L. Brady, and Martin Deutsch on neutron physics; and Theodore A. Welton, '39, Herman Feshbach, '42, and Victor F. Weisskopf on theoretical physics.

Diamond-Studded Amplifiers

MEANS for amplifying electrical currents through use of suitable control systems are certainly no longer novelties. Electromechanical amplifiers were first tried in telephone systems between Boston and Amesbury, Mass., as early as 1904, and were used commercially on circuits between New York and Chicago between August, 1904, and February, 1905. By 1912 the audion which DeForest invented in 1906 had been developed into a very much improved electronic amplifier and oscillator which was practical in every respect. Virtually all modern radio receivers use one (or more) tubes as oscillators and several tubes as amplifiers. Thus, a foremost scientific novelty of four decades ago has become a household necessity today.

If history is to repeat itself, recent research by Kenneth G. McKay, '41, and his associates at the Bell Telephone Laboratories, holds forth the possibility that amplifiers of the future could very well be diamond-studded. Such a possibility does not indicate a return to the ostentation of a Jim Brady. Rather does it come about as a logical conclusion of research which has brought to light a radically new method of controlling the flow and amplification of electric current which may have far-reaching influence on the future of electronics. The method is based on the discovery that a beam of electrons shot at an insulator — diamond chips in this case — may release currents which are several hundred times as large as that in the original electron beam.

The technique holds promise of opening up a new approach to the design and use of certain types of electron tubes. It makes probable the development of important new electron tubes which do not exist today, particularly for use at very high frequencies. The new technique for producing currents from insulators by electron bombardment (much as currents are released from photoelectrically active conductors activated by light) is expected to supplement rather than replace existing electronic techniques.

Dr. McKay's work is also expected to be of considerable theoretical value, for it provides a new and powerful tool with which scientists hope to learn more about the fundamental structure of solid matter and how it behaves under the impact of electrons.

The experiments of Dr. McKay using electron bombardment stemmed directly from previous pioneer research in which current was induced in diamonds by bombarding them with alpha particles, those relatively heavy, positively charged bits of matter shot off by radioactive substances. The earlier investigation promises development of a new and improved laboratory tool for detecting and counting alpha particles. Such a device would do essentially the same thing as the familiar Geiger counter but appears to offer the advantages of smaller size, lower operating voltage, and a faster counting rate.

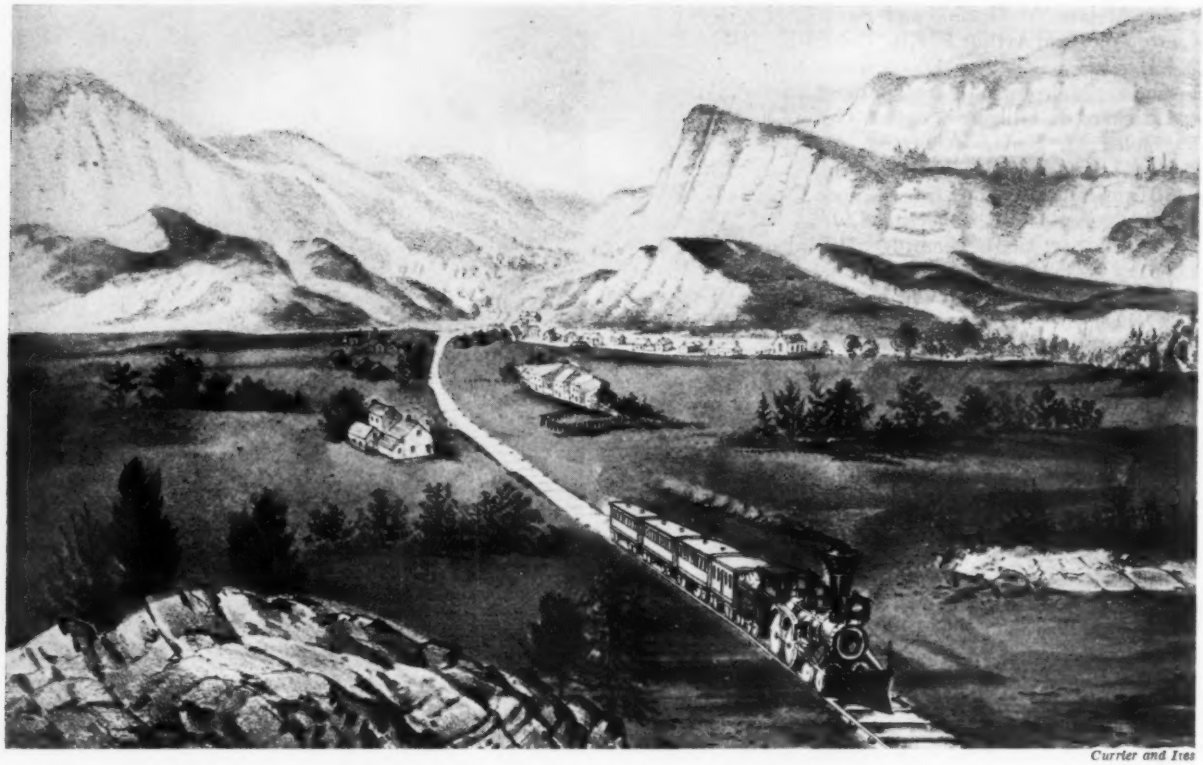
Bell Telephone Laboratories

In pioneer experiments conducted by Kenneth G. McKay, '41, at the Bell Telephone Laboratories, tiny diamond chips, bombarded with a beam of electrons, have been found to yield electric currents as much as several hundred times as large as the original beam. This new method of controlling the flow and amplification of current may have far-reaching influence on the future of electronics. A. J. Ahearn, who was associated with Dr. McKay in the investigation, is shown placing the mounted diamond chips in a test circuit to check their induced conductivity under alpha particle bombardment, an associated phase of the research.

Inducing electric currents in diamonds by bombarding them with relatively lightweight electrons proved to be considerably more difficult than bombardment with alpha particles. It was found that electrons became trapped in the tiny imperfections which are present in all crystals so that after the first fraction of a second, the induced current tended to waste away under the opposition of the trapped electrons.

To overcome this blocking effect an alternating voltage was applied to the diamond chip so that current flowed through the diamond one way for a fraction of a second and then in the other direction, reversing itself 120 times a second. Alternately negative and positive charges are drawn through the crystal and some of each kind are trapped. The positive charges thus collected neutralize the effect of the trapped, negatively charged, electrons, and the induced current is allowed to flow freely.

An important feature of this new technique is that the induced currents are produced so quickly that it has not been possible to measure the time required for their production. It appears certain, however, that less than one ten-millionth of a second is required for such currents to become established.



Currier and Ives

Road to Fortune

Congressional Lobbying, Indian Fighting, Superb Engineering — All Entered into the Construction of the First Transcontinental Railroad

By E. H. Cameron

As an example of skillful engineering organization, the building of the Pacific Railroads was outstanding. It was also one of the most dramatic American performances of the Nineteenth Century, in public interest far transcending any modern construction venture. This drama was played on the huge stage of the Great West, from the prelude of daring explorations to the stirring scenes of activity from Sacramento to Omaha, with the scene often shifting to political Washington where the huge government grants were decided upon. Presidents Lincoln, Johnson, and Grant played their roles in crises requiring executive decisions; would-be presidents damaged their political chances by their inept performances during the acts of this great drama. There were financiers with keen foresight and speculators of shrewd daring: Durant, the Ames brothers, Stanford, Huntington, Charles Crocker, and Hopkins. The fine traits of character and superior technical genius of the outstanding engineers of the cast, Theodore D. Judah and Grenville M. Dodge, became readily apparent as the play progressed.

The lesser characters of the play — surveyors, bridge builders, graders, and tracklayers — went armed. For bands of Snakes, Crows, Blackfeet, Arapahoes, and Sioux, made desperate by brutal aggressions of the white race, were on the war path, and killed hundreds of workers and engineers before the railroads were completed. Such was the price of railroad progress.

With increasing tempo, the drama went on; records of railroad construction were shattered, and in the sixth year, an audience consisting of all America watched the race of the Union Pacific building westerly, with the Central Pacific laying its tracks toward the East. The climax was melodramatic, when the two lines met at Promontory Point, Utah, on May 10, 1869. Bearded railroad officials drove gold and silver spikes in a polished laurel tie, bearing an inscribed silver plate, while soldiers, Mormon elders, and emigrants looked on. The silver track sledge was wired to make an electrical contact, which operated telegraph receivers in cities and towns from San Francisco to New York. Wine flowed freely, and Bret Harte wrote a poem:

> What was it the Engines said,
> Pilots touching, — head to head
> Facing on the single track,
> Half a world behind each back?

Two Engineers

The names of two engineers are outstanding in the Railroads' story: Theodore Dehone Judah for the West and Grenville Mellen Dodge for the East.

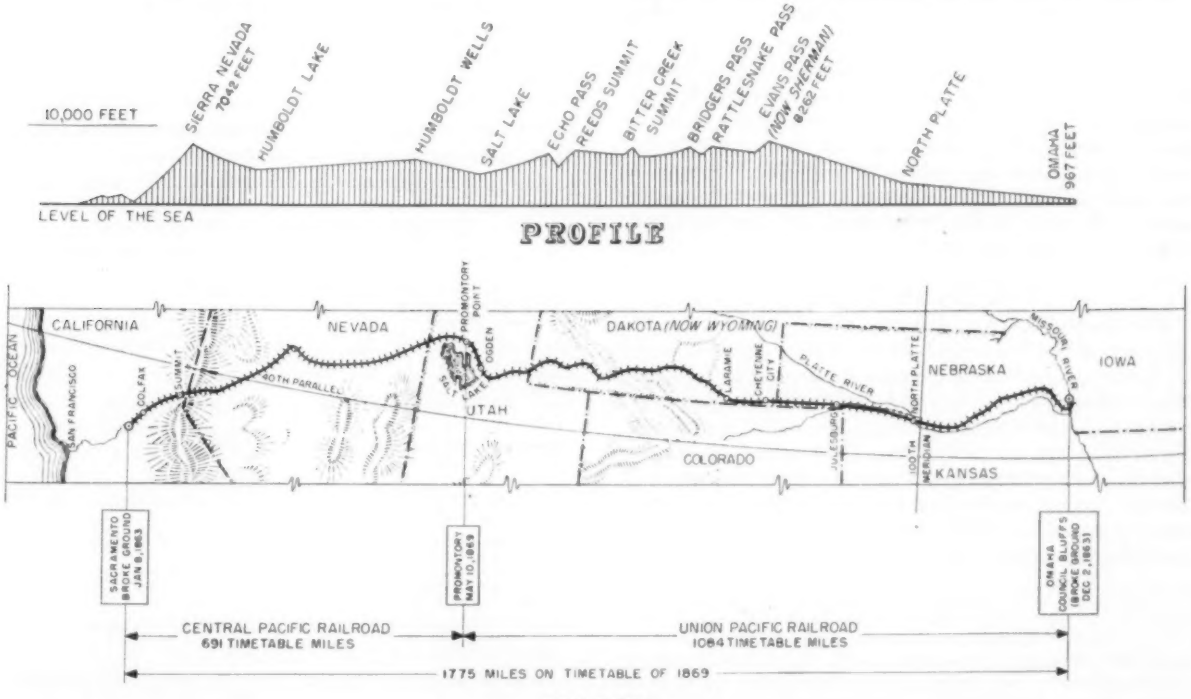
Judah, who died when not quite 38 years old, was a genius at building railroads. Born in New England, a graduate of Rensselaer Polytechnic Institute, with a fine record on railroad work, he became obsessed with a single idea. It was his ambition to become the engineer who should construct a continental railroad across the Great West. He was called an enthusiastic lunatic — a fanatic. He became the first chief engineer of the Central Pacific Railroad Company, but died when construction had barely started. The genius and courage of Judah were exhibited in his determination of a suitable Sierra crossing. It was, like many examples of genius, a simple solution, as subsequent paragraphs will reveal.

Grenville M. Dodge, of the Union Pacific, was five years younger than Judah. He was a Massachusetts man, a graduate of Norwich University, who, after a period of railroad survey work, entered the United States Army. He rose to the rank of major general of volunteers in the Civil War and, in the year 1866, resigned from the Army to become the chief engineer of the Union Pacific Railroad. With the successful completion of this project Dodge turned to railroad construction in the Southwest and elsewhere. Throughout his long life his advice and organizing ability were called upon in railroad enterprises in America, Russia, China, and other countries.

Reconnaissance

To plan the 1,775-mile long line from Omaha to Sacramento, traversing plains, foothills, and mountains, all of the problems of railroad location would be encountered. Studies would have to be made of ridge and valley lines, of passes, and tunnels; practical locations determined for the short-span bridges, mostly of timber, that were then feasible. Skillful reconnaissance would be required to find answers to difficult questions. Would it be at all possible to find a path which could be laid out within the limits of allowable curves and grades? What would the railroad cost? Would the huge expense be justified by the explorers' reports on the resources of the country to be served — the resources of gold, silver, lead, and timber, not to mention the agriculture to be developed naturally or with the aid of irrigation? From Omaha west for several hundred miles, it would, obviously, be good judgment for railroad curves and grades to conform to the trail used for centuries by buffaloes and Indian tribes, and via which Mormon emigrants had made their heroic trek to the West, that is, along a section of the famous Oregon Trail. Today, Route 30, the Lincoln Highway, parallels this early trail for many miles.

In 1857 a report of the War Department was issued, which was entitled "Explorations for a Railroad Route from the Mississippi River to the Pacific." Jefferson Davis, as Secretary of War, signed this monumental report, which compared the merits of several railroad routes. Handsomely illustrated, and with many maps, this 11-volume document recorded the results of exhaustive explorations of plains, mountains, and desert areas of the regions explored; it gave extensive data on meteorological conditions, plant life, and beasts — bison, antelope, and elk, which were to be shot at from the car windows of the completed Pacific Railroads 12 years later. The names of army lieutenants and captains, who became high-ranking officers in the ensuing Civil War,



Plan and profile maps of the western part of the United States give a thoroughly inadequate impression of the difficulty and magnitude of the task of joining Omaha and Sacramento by rail at Promontory Point in 1869.

Surveying the routes for transcontinental railroad lines was no easy task as this party in Humboldt Pass indicates. Chief Engineer Judah of the Central Pacific estimated that reconnaissance surveys for a transcontinental railroad would cost $200,000. His estimate mentions transit shots 1,000 feet long, with angles turned by goniometer. Levelers would set benches at about one-mile intervals which check-levelers would verify. Each party would have two hunters, at $40 per month, to supply meat. Horses for transport would cost $100 each.

appear in this report. Captain George B. McClellan's report [1] on existing railroad standards was highly commended by Jefferson Davis, the future President of the Confederacy, praising the ability of the man who was soon to command the Union Army of the Potomac. It was only natural that Jefferson Davis should heartily endorse the route of the 32d parallel, the most southerly of the surveyed locations.

Field Day for Lobbyists

The Great West was that part of the United States to the west of the Mississippi River. To all Americans and to hordes of Irish and German immigrants, the Great West offered adventure and riches. Gold and silver awaited the adventurous. For more sober people, the Homestead Act of 1862 offered great farms; there were timber, and vast areas for the grazing of cattle and sheep. Drawn by oxen and mules, trains of wagons, frequently one quarter of a mile in length, had borne thousands to the fabulous regions of the Great West. Checking off their daily progress of from 12 to 20 miles per day, the emigrants prayed for a railroad along this road to fortune.

As a war measure, the first Pacific Railroad Act was passed in 1862, to foster the loyalty of the western territories in the Civil War. The Congress of 1862 was in an economical mood; it was frightened by a national debt which two years of war had multiplied by three. Its land and bond grants were inadequate for the tremendously speculative venture which presented apparently insurmountable difficulties of construction — a railroad, across hostile territory. Private capital just wasn't interested.

Railroad lobbyists flocked to Washington to convince Congress of this undoubtedly true condition. The lobbyists were persuasive. The next — more generous — Congress, now acclimated to the inflationary atmosphere of a national debt of about $1,600,000,000 passed the supplementary Act of 1864, the grants of which proved much more attractive to private capital. This and other acts gave grants in land and United States bonds to the railroads as follows:

(a) Land grants of 10 alternate sections per mile, on each side of the line, which averaged 12,800 acres per mile.

(b) $16,000 per mile between the Missouri River and the east base of the Rocky Mountains, and from the Sierras to Sacramento.

(c) $32,000 per mile from the Rocky Mountains across the Great Basin.

(d) $48,000 per mile across the Rocky Mountains and the Sierra Nevadas.

The Pacific Railroads were built in what has been well called the Tragic Era of American political life. Speculation was rampant and graft was common. A somber highlight of this era was the Credit Mobilier scandal, involving the promoters of the Pacific Railroads. Inquisitive persons, noting the huge gifts to the railroads, wondered how much the railroads had given to the members of Congress, including a future vice-president of the United States.

Two main railroad arteries were in existence from the East Coast: the upper line to Chicago, to be extended by three proposed lines across Iowa, which would converge on Council Bluffs, and the lower line to St. Louis. Pro-

TABLE I — HISTORICAL PARALLELS

Pacific Railroads		*Contemporary American Events*	
		Civil War	
Organization of Central Pacific RR of California	July 1861	Fort Sumter	Apr. 1861
First Pacific Railroad Act	July 1862	Naval battle of Monitor and Merrimac	Mar. 1862
Central Pacific RR broke ground	Jan. 1863	Emancipation Proclamation	Jan. 1863
Union Pacific RR broke ground	Dec. 1863	Gettysburg	July 1863
Second Pacific Railroad Act	July 1864	Early's raid on Washington (Confederates within six miles of Capitol)	July 1864
Central Pacific RR reached Auburn (36 miles)	May 1865	Appomattox	Apr. 1865
		Postwar	
Union Pacific RR had laid 40 miles of track from Omaha	Jan. 1866	Atlantic cable (first successful)	July 1866
Union Pacific RR had laid 305 miles of track (beyond North Platte)	Jan. 1867	Purchase of Alaska from Russia	Mar. 1867
Central Pacific RR reached Sierra Summit (105 miles)	Sept. 1867		
Union Pacific RR had laid 540 miles of track (between Cheyenne and Laramie)	Jan. 1868	President Andrew Johnson impeached (acquitted)	Feb. 1868
Railroads met at Promontory Point	May 1869	President Grant inaugurated	Mar. 1869
		The Great Chicago Fire	Oct. 1871
Missouri River Bridge at Omaha completed, making a complete railroad line across the continent	Feb. 1872	The Great Boston Fire	Nov. 1872

[1] Shortly, McClellan was to become president of the Illinois Central Railroad and attain a high reputation in this position. A little later, early in the Civil War, he was to be appointed commander of the Union Army of the Potomac by President Lincoln. His qualifications for the earlier position are well verified by his comprehensive report on the Pacific Railroads from which later quotations will be made. As to the latter post, historians quite universally rate him as a discredited military commander; but the record shows him to have been a good railroad engineer.

motion was by three groups of financial interests, representing:

(a) *The Central Pacific Railroad Company.* This railroad was to build east from Sacramento, to cross the Sierra Nevada Mountains and end near the Great Salt Lake;

(b) *The Union Pacific Railroad.* Fostered by Chicago interests and having close bonds with a financial group styled the Credit Mobilier of America, the U. P. was to build west from Omaha, and join the Central Pacific at Great Salt Lake;

(c) *The Kansas Company.* This St. Louis group sought to beat the Union Pacific by building the Leavenworth, Pawnee, and Western Railroad to the 100th meridian, and thus be legally designated as the eastern section of the transcontinental line. Internal dissensions in this company soon caused it to give up this attempt.

Construction Standards

American railroads had passed through their infancy [2] and had reached a stage of development in roadbed and rolling-stock standards very similar to that of the present time. Instead of individual stone blocks for supports and continuous strap rails on squared timber, inverted iron tee rails on wooden cross ties were now preferred. Cut and fill could be computed by Professor W. M. Gillespie's tables, not too different from modern ones. The need for adequate waterways at culverts and bridges to care for floods was recognized. Thick, well-drained ballast was considered necessary. The outer rail on curves was elevated according to definite tables, to give one indication of the status of railroad design of the period. Wrought-iron chairs under the rail joints were being supplanted by fishplate joints. Axles were fixed to, and turned with, the flanged wheels as at present, and this was recognized as a reason for the additional power needed on curves.

The Pacific Railroad Act allowed curves as sharp as those on certain sections of the Baltimore and Ohio Railroad (400-foot radius), but such curves were limited to the mountainous regions, in recognition of the "evils of curves." Likewise, although allowed by the Pacific Railroad Acts, grades as steep as the Baltimore and Ohio maximum of 116 feet per mile were restricted and the tracks were kept as near level as possible. The advantages of the undulating railroad were now admitted to be fallacious; it was agreed that a train could not gain enough momentum going down one hill to carry it up the next, and so to keep running forever.

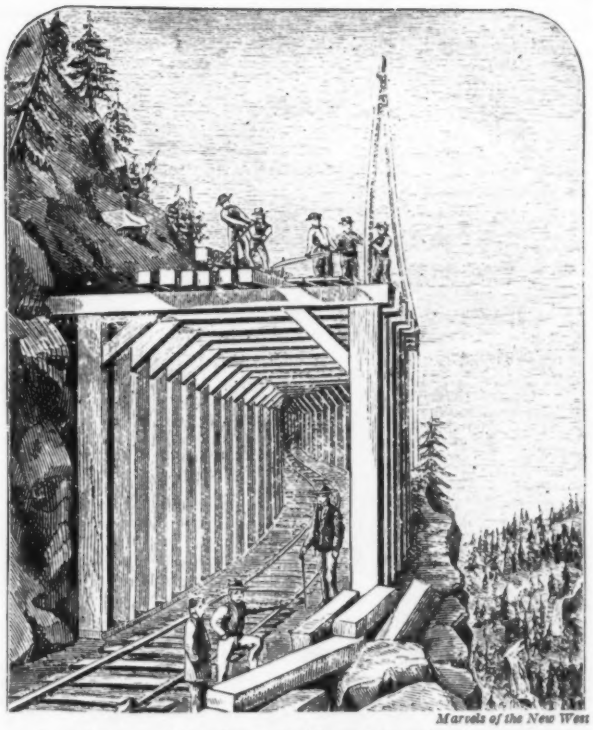
TABLE II — COMPARISON OF STEAM LOCOMOTIVE CHARACTERISTICS

Characteristic	*1875 Baldwin 10-wheel*	*1941 * Union Pacific 4-6-6-4 Freight*
Date built	About 1875	1937
Weight of locomotive in pounds, excluding tender	78,000	582,000
Number of drivers	6	12
Diameter of drivers	54″	69″
Total number of wheels, excluding tender	10	20
Wheel base, excluding tender	23′6″	59′11″
Cylinders		
Number	2	4
Diameter	18″	22″
Stroke	24″	32″
Grate area, square feet	14.4	108.2
Total heating surface, square feet	1,108	5,381
Total weight in pounds on driving wheels	58,000	403,000

Note: 1875 data from Forney's *Catechism of the Locomotive*, 1875 edition. 1941 data from Mark's *Mechanical Engineers' Handbook*, 1941 edition.

* The dimensions and power of a modern steam locomotive have been well summarized. ". . . As a self-contained power plant, it has no rival — 100 feet long, 15 feet high by 12 feet wide and producing 7,000 cylinder horsepower." (H. A. F. Campbell, '99, *The Technology Review*, June, 1947.)

[2] The early growth of railroads in the United States is readily evident when it is recalled that in 1830 only 23 miles of railroads were in operation. By 1868, however, the corresponding figure was 42,255 miles.



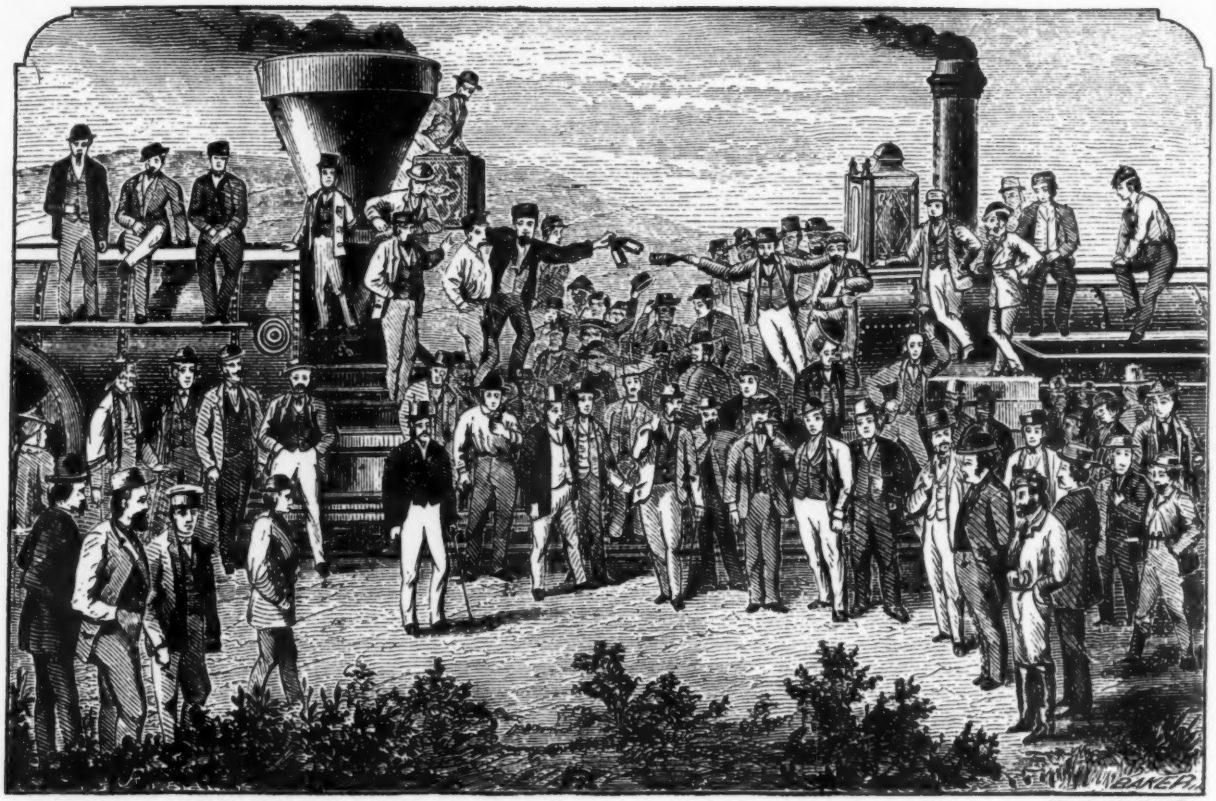
Marvels of the New West

In a distance of 40 miles in the Sierras, 32 miles of snow structures were built by the Central Pacific Railroad. The gallery type, shown here, was built alongside the mountain and was designed to withstand the impact of snow slide. The shed type was designed to carry the weight of a level snowdrift on its roof. That such loads were considerable may be judged from the fact that one such drift measured 50 feet deep. Fire hazard was high since snow sheds were built entirely of wood.

Locomotives and cars were tiny prototypes of those of today. The mean effective pressure throughout the stroke was checked by a steam engine indicator, which drew a diagram like a modern one. There were steam tables up to 300 psi (absolute), coal analyses were tabulated much like the present standards, and there were steam domes, safety valves, and sand tanks. In Massachusetts, the McClellan Report stated, engines usually carried a pressure of 100 pounds in the boiler; the strength of the boiler was from 350 to 500 pounds (the designation "psi" is not given, but may be presumed). McClellan referred to the possibility of condensing the exhaust steam, and cited an example of this practice in Scotland. He reported that four- to seven-car trains of the Boston and Maine Railroad traveled at a speed from 24 to 34 miles per hour.

A most expedient report was submitted by a board of the Corps of Engineers, United States Army, on standards for the construction of the Pacific Railroads in 1866. Faithfully, this report collected data on American railroad standards. Rigidly, the report adhered to the suggestive "should be," rather than the mandatory "shall be." No standard, it implied, should be allowed to interfere with speedy completion, an admonition that was taken in earnest, as the size of the later "Deficiencies of Construction" account made apparent.

Cross ties of oak or other suitable material should be used where such ties could be obtained with reasonable



Marvels of the New West

At Promontory Point, near Ogden City, Utah, 1,775 miles of railroad were joined on May 10, 1869. Some of the celebrations of the "Last Spike Ceremonies" are recorded in this woodcut engraving probably cut from a photograph made on the occasion. The last spikes included one of gold from California, one of silver from Nevada, and one of gold, silver, and iron from Arizona. A solid silver hammer was wired into telegraph circuits to ring bells in San Francisco and to telegraph news of the completed rail line to Baltimore, Philadelphia, Boston, New York, Cincinnati, and Chicago. The silver-plated tie of California laurel was then removed and was replaced by a pine tie for the relic hunters to splinter. Several replacements were used up in quick succession.

transportation. But, if cottonwood or similar soft material were used, the ties must be burnettized (zinc treated). There should be at least 2,400 ties per mile although the eastern practice was said to be 1,700 ties per mile. Rails must be of American iron, because the Act said so, and should weigh 60 pounds per yard; but rails as light as 50 pounds were allowed. As the nearest approximation to a continuous rail, the so-called fish joint was preferred, but, if this would retard the progress of the work, the common American wrought-iron chair could be used. Sidings totaling at least six per cent of the length of the line should be laid for we must remember that the original transcontinental line was a single track railroad. Cattle guards and road crossings were called for.

This reasonable specification, conceding so much to the speed of construction, still resulted in the building of a good railroad. While many improvements were later required, contemporary and later inspections commended the unusually well-selected location of the line and the faithfulness of construction. If revised to call for today's much heavier rails and rolling stock, the specification might serve for a modern railroad.

Battle Prodigious

Abraham Lincoln, former surveyor, made a wrong decision in a dispute regarding the gauge to be adopted on the Pacific Railroads.[3] The California charter, under which the Central Pacific started its line, called for a gauge of five feet. Obligingly, Lincoln decreed that this gauge should be followed throughout. An Act of Congress was required to allow construction of roadbeds with the narrower gauge of four feet, eight and one-half inches which had recently been adopted by several large American railroads and which is today adopted throughout the United States.

It was natural that General Dodge should adopt a semi-military organization for his construction force which built the Union Pacific Railroad westward from Omaha. It was unusual that Charles Crocker, small dry goods merchant turned railroad construction superintendent, should exhibit the bold, organizing genius that was called upon to meet the difficult problems involved in the building of the Central Pacific Railroad from Sacramento easterly. Audacious means were adopted by both railroads to organize their huge construction forces, to obtain the vast quantities of materials, from remote sources of manufacture, and to deliver them to the ever

[3] Lincoln's name appears frequently in the railroad story. His nomination for president was strongly backed by railroad promoters; as president he selected its eastern terminus (Council Bluffs, as later confirmed by the Supreme Court); he advocated the amendment of the first Act, and he was quoted as saying that the proudest event of his life had been the signing of the bill in aid of the Pacific Railroads.

receding "end of track." [4] Before keeping his promise to become chief engineer of the Union Pacific, Dodge remained in the Army long enough to organize the campaign that was to curb the Indians sufficiently to allow construction to go on. The record of massacre of troops, settlers, and railroad builders in the Indian Wars immediately after the Civil War is still somber reading.

For the Central Pacific, all rolling stock, and all construction material except timber and stone, had to travel on vessels, via Cape Horn, or by transfer across the Isthmus of Panama. With materials ordered a year ahead, prices were fantastic, and heavy freight rates were enhanced by war risk. Engines arrived knocked-down at San Francisco, were shipped by lighter and boat to Sacramento, and assembled there. A similar situation existed for the Union Pacific at the start. Rolling stock, rails, and ties for the treeless miles of Nebraska had to be transported by wagons or boats, for the railroad system from Omaha to the eastern states still lacked tracks for a long stretch across Iowa.

For the Central Pacific the labor shortage caused by the Civil War was made more acute by the natural desire of workers to make $4.00 a day at the mines as against $1.00 to $2.00 on the railroad. Superintendent Crocker met this difficulty by calling for Chinese coolies. On the Union Pacific, however, there were many Civil War veterans available by the time construction really started. Almost every railroad worker on this line was an ex-soldier, Union or Confederate, according to one account.

A few months after the breaking of ground by the Central Pacific, its first chief engineer, Theodore Dehone Judah, died. In the location of the line his influence continued after his death. His outstanding contribution was the determination of the route of the Sierra crossing, as ascertained by his personal surveys. As they had built their roads for generations, and their railroads for decades, engineers had followed the streams and rivers, that is, they had kept to the valleys. For the steep slopes of the Sierras, such a course would be blocked by almost vertical, granite cliffs; tunnels of dimensions to pierce such an obstacle were then impracticable. Judah's solution to this dilemma was as simple as it was effective, for the Central Pacific line followed the ridges. In Judah's words: "The line on top or crest of ridge being far from uniform, of course the lowest points or gaps in ridge become commanding points, and it was found necessary to carry the line from gap to gap, passing around the intervening hills, upon their side slopes." The route, with its steep grades, would cross the Sierras in the vicinity of Cascade and Summit, at an elevation of slightly over 7,000 feet. The men who were making millions yearly from their stage and wagon lines to the mines of Nevada called Judah's route the "Dutch Flats Swindle," and said that it would end high in the air and be a waste of money.

To get down to normal terrain once the Sierras were crossed, the Judah plan would now adopt the standard procedure of following a valley, that of the Truckee River. The railroad should follow the Humboldt River, in Nevada, and thence to Utah. Climate and terrain combined to make the Central Pacific a frightfully difficult line to construct. Snow drifted in banks to the unbelievable depth of 60 feet, and snow tunnels were needed to reach the face of rock tunnels. At one time 5,000 men were employed in shoveling snow; they made excavations in snow caves, with the spoil passed out through shafts of snow. In the cutting of 15 tunnels, including the Summit Tunnel, one-third of a mile long, gunpowder and even nitroglycerine (an early experience) were used. A force of 11,000 Orientals, 2,500 Caucasians, and 1,000 teams of horses were at work. Such are highlights in the story of the building of the line of the Central Pacific Railroad. What of the Union Pacific?

A figure of legendary proportion in the saga of the Union Pacific Railroad was General Jack Casement. General Jack is said to have marched his men to the job in military formation; they would (*Continued on page 278*)

[4] Those who struggle with the present huge volumes of the Poor and Moody's series of financial manuals would find much easier to handle the little *Manual of the Railroad of the United States, 1869–70*, by Henry V. Poor. One hundred pages of advertising, spotted with fine woodcuts, reveal how old are so many of today's items of railroad equipment. Early frogs, safety valves, and snow plows are illustrated, as well as devices representing embryonic attempts to solve such problems as the proper joints in rails, and car heating. Timber and steel bridges, locomotives, and cars of all sorts are displayed as are also shop equipment and tools for building railroads in the field. Automatic couplings are described but the reader would need to turn to the contemporary *Catechism of the Locomotive* of Forney for a complete description of the air brake and the steam engine indicator.

While the problem of delivering this material was tremendously difficult, the supply of railroad rolling stock and track equipment was ample for the huge orders of both the Union Pacific and the Central Pacific.

Harper's Weekly

During the construction of the transcontinental railroads Indian attacks, such as this of the Cheyenne Indians on a working party of the Union Pacific Railroad were not uncommon. Chiefs of survey parties and road laborers were among the hundreds killed during the construction of the railroads.

Food, Fuel, and Faith

The War Proved Soundness of the American Way of Life. Great Strength and Enormous Reserves of Power Come from a Nation's Free People.

By Karl T. Compton

Commencement Address

GRADUATION is a very significant event. It is worth our while to spend a few minutes to recall what it really means. Classes come and classes go with what sometimes may seem, in the history of the college community, the monotonous regularity of a railroad schedule. But each class has its individuality, and is made up of individuals, for each of whom this ceremony is the climax of that first period of life which is devoted to three things: development of a healthy body, development of a trained mind, and development of a sound character. This body, mind, and character are the foundations for the work and play, the achievements and satisfactions, to which the rest of life is devoted.

Throughout the years tens of thousands of public-spirited persons, actuated by generous affection for young people and by faith in the value of education to our society, have contributed the funds which have created the endowment and the physical plant of M.I.T. Our government has granted tax exemption to aid this worthy cause of education and, grateful for the services and sacrifices which so many of you made for your country in World War II, has assisted many of you financially to secure this education. More than a thousand staff members of this institution have devoted themselves to help you secure it.

In some 500 homes your graduation today is the cause of deep satisfaction and the realization of long-nourished hopes, and many sacrifices. I was made to realize this on the occasion of my own graduation when my father, in a rare burst of emotion, said to me: "My son, this is the proudest day of my life." This feeling is in many hearts today.

Yes, your graduation is an event of real significance. You have worked hard and successfully. Your training is of unexcelled quality. Your future is before you. On behalf of the Corporation and Faculty of this institution I congratulate you.

My parting message to you concerns this future, and the conditions you will meet as you enter it. As a text, I have taken the words by which a distinguished general recently epitomized the needs of the war-ravished countries of Europe. "These people need," he said, "food, fuel and faith; but most of all they need faith." For without some basis for faith in their future, food and fuel will only postpone their disintegration. I should like to make two applications of this text: first to the United States as a nation, and second to each one of you individually, whether you are citizens of the United States or guest students from some other country.

Food and fuel may be taken to symbolize the necessities and comforts of life. Of these, our country is blessed with an abundance surpassing any other people in history or any other nation in the world today. This is partly due to the richness of our natural resources of fertile agricultural land, of minerals and fuel, of forests, rivers and lakes, of temperate climate. It is partly due to the inherited pioneering spirit and the virile admixture of the sturdy stock of many nations. It is partly due to a heritage of freedom, won and preserved by struggle and sacrifice, in which there has been great opportunity for free initiative by which each person has the chance to follow a career of his own choosing. The limits of his success are set by his own ability and by the free competition of his fellows, but not by traditional class distinctions or by governmental regulations.

Under these conditions we have achieved a standard of living which is the envy of the world. Our natural resources have been exploited by unprecedented technological methods to multiply by many fold the traditional per capita productive power. We produce more, and have more, with less work. To be sure, we have our problems, but they are problems of distribution and planning and management — not problems of national poverty. They are problems of wise conservation as opposed to extravagant waste, of future technological development rather than present scarcity, of maintaining our free enterprise system against the mass pressure of minority groups seeking selfish advantage by coercion or political lobbying rather than by virtue of their productive contribution to the general economy. But we have the basic resources, the basic skills, and the momentum of progress to insure food and fuel, and all the other factors which constitute the necessities and the comforts of life, and a reasonable lot even of luxuries.

With your technological training, you will be well prepared to make your contributions to this program of production — to maintain it, to raise it to still higher standards of efficiency, and to make the modifications required by new demands and changing conditions; and if past experience is any guide, these demands and opportunities will be great during the period of your active careers.

But turn now to the subject of faith, for without faith, food and fuel cannot make a great and strong nation. Are we in danger of becoming like the man who gained the whole world but lost his own soul? Let us look at the evidence.

I have presented part of the evidence. We have achieved a standard of living, based on technological developments in industry and agriculture, which far surpasses that of any other nation in history. When we became involved in World War II, we rallied to meet the crisis in astonishing strength. (*Continued on page 288*)

Psychology, Men, and Machines

Design and Effectiveness of Control Mechanisms Materially Improved by Contributions of Psychologists

By W. Mack Angas

THE pilot, copilot, and navigator of a large naval seaplane were being briefed for a long overseas reconnaissance. The flight engineer of the plane was called in to hear a final summary of the instructions and advice given by the squadron commander.

"The take-off from the atoll where you are to pick up Lieutenant Commander Maley and his part of Seabee surveyors will be the toughest spot in your trip. With their equipment, they'll load the plane heavily. As you see," and he pointed to a chart, "you can't get a run of more than two miles in the lagoon."

"How about taking off from the open sea?" asked the copilot.

"I don't advise it. There'll be a long swell that may get you into serious trouble. Of course you'll consult Maley as to the best water for your take-off run. He and his party have been surveying the lagoon."

"Has he any aviation gas with his outfit that we can pick up at the atoll?" asked the flight engineer who knew that the survey party had gone out by ship with the intention of flying back when their field work had been completed.

"Unfortunately not! And you'll have none too much for the long hop from there to Kwajalein. Keep a close check on your 'points of no return' throughout the trip, and especially on that hop. And let me repeat my caution about the predawn take-off from the lagoon. It's going to be the toughest spot in a tough flight."

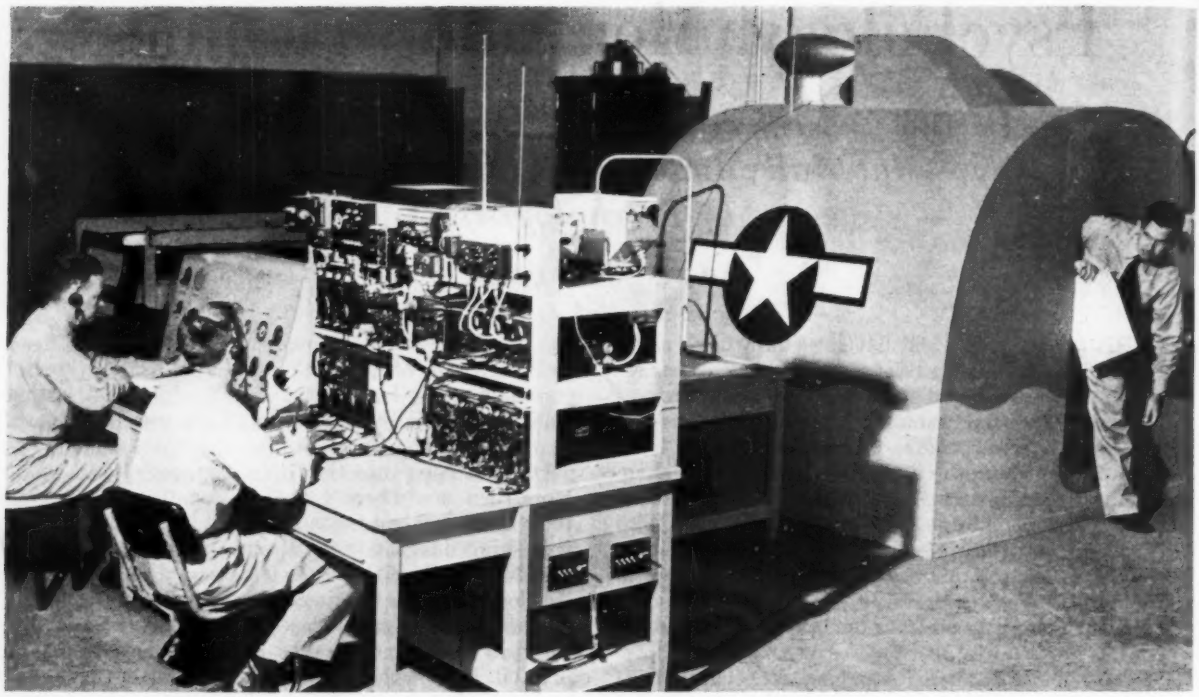
On the following morning, the crew of the big Martin Mariner prepared for this take-off. Carefully the officers and men of the big flying boat went over their checkoff lists to make sure that everything was as it should be before they started. A few minutes later, the roar of the plane's two big engines announced the start of the take-off run. The roar became higher in pitch, and then instruments indicated that the hull had left the water and the 20-ton plane was nosing up into the blue-black sky of a tropic night. They could see practically nothing ahead and must trust their instruments.

All went well until, with only 50 feet altitude, the mounting roar of the two engines faltered and the flight engineer sensed a sudden loss of acceleration. Galvanized into action, he frantically checked the many gauges, dials, lights, and control settings on the panel before him. That telltale red light! He hadn't seen it and it meant a dangerously low fuel level in his forward tanks! A quick switch to the center hull tank, a furious operation of the wobble pump, and the engines resumed their steady, full-voiced roar. But now the pilot had to make an instantaneous decision. Should he continue his flight and hope to regain the precious lost altitude, or try to get back down onto the water in the dark? He elected to go on. But there wasn't enough room! They could never clear the fringe of coconut palms on the rim of the atoll surrounding the lagoon, the details of which they had studied so carefully on the chart. There was neither sufficient altitude nor space to turn.

Oh, well! Next time they'd do it properly! And what's more, there would be a "next time" for all of them because the whole affair had taken place, not in a seaplane over a palm-fringed lagoon in the Pacific, but in a laboratory of the Navy's Special Devices Center. Here the Navy develops and tests training devices which simulate actual operating conditions so closely that students learn to do the right thing in common types of emergency from force of habit. In fact, the utilization of training devices of this type to indoctrinate pilots in the use of new techniques and instruments, such as ground control approach, instrument landing systems, and radar should materially reduce the hazards of flying by transmuting many present-day emergencies into mere incidents.

The development of training devices that simulate

The student flight engineer, seated at the control panel shown here, undergoes all experiences of handling the motors of a Martin Mariner in various types of emergency except that of danger. When undergoing training, he sees dial readings as they would appear in an actual operation of the plane, and even hears the characteristic sound of the motors under various conditions through a loud-speaker system.



The hut which a student officer is leaving is the navigator's hut, and contains all the navigational equipment of a large plane. In it the student navigator may have practically all of the experiences of navigating a patrol plane on a long flight.

actual operating experience so completely as to include the reproduction of characteristic sounds through loud speakers is, however, only one of the functions of the Center. Here in laboratories and offices located at Sands Point, Long Island, the Navy plans, directs, and partially executes its program of applying the knowledge of the psychologist and physiologist to the many engineering problems to which such knowledge is applicable. These problems are varied in character. One deals with designing and arranging the control mechanism of machines and instruments so as to minimize the operator's burden. A closely allied problem involves the development of techniques by which operators can use existing types of control gear with increased effectiveness and decreased fatigue. A third question of great importance is determination of the limitations of operators' tolerances. What accelerations, for example, can dive-bomber pilots stand in pull-outs and how much oxygen must an interceptor pilot take during a sustained flight at an altitude of 20,000 feet in order that his judgment may not be impaired by oxygen deficiency? Of these problems, the one involving the design of control gear is perhaps of the greatest immediate importance.

The problem of designing control gear so as to minimize the difficulty of the operator's job is not a new one, and reasonably satisfactory solutions of it were long ago developed in certain fields by the evolutionary process of trial and error. For example, the console of a large pipe organ with its superimposed keyboards, pedals, and stops, forms an almost perfect control system by means of which a single operator can handle an extremely complicated machine by effectively using both hands and feet. That the mechanism produces nothing more than sound, does not in any way lessen the interest of the designing engineer in the console as an outstanding example of the effective arrangement of the controls of an exceedingly intricate mechanism. In fact, one's admiration for the skill of a fine organist may well be matched by admiration for the skill of the organ builder who placed, within reach of a single musician, the control of valves admitting air to as many as 30,000 pipes.

The standard keyboard of the typewriter affords another good example of an effective control arrangement that has been developed by an evolutionary process. The arrangement of the keyboard could be improved although any change would be a handicap to typists skilled in the use of the present keyboard.

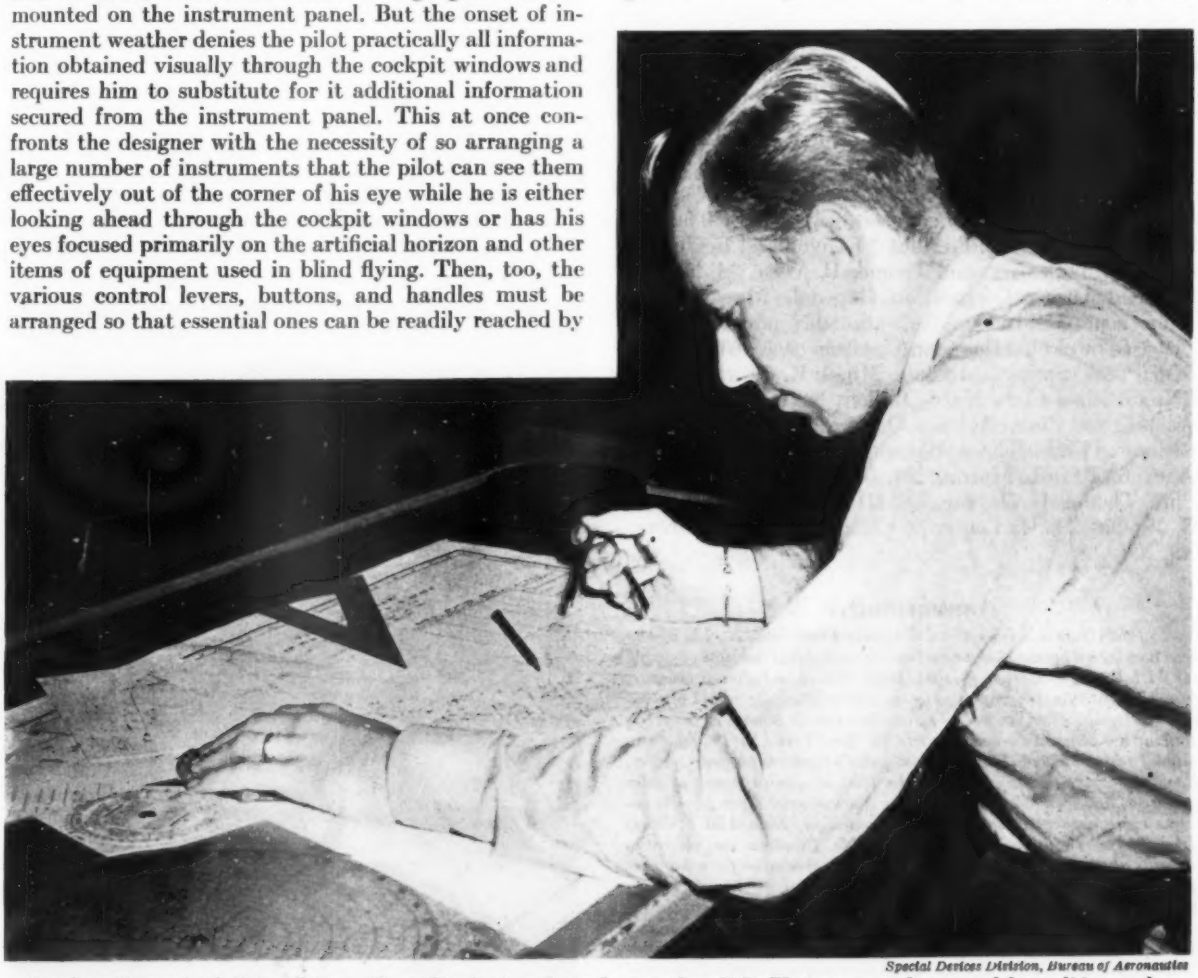
On the other hand, the process of evolution has made poor progress in other less familiar fields than the development of the organ console and the typewriter. The navigator's sextant, for example, superseding Hadley's octant on which it was based, is an instrument the essential left-handedness of which was not realized until aviators began to use it about two centuries after its prototype was invented. It would be interesting to know whether or not Hadley was, in fact, left-handed, for he built his sextant to be held in the right hand while the left hand is called upon to operate its clamp and tangent screw. Not only does this call upon the left hand to do a job requiring a certain amount of dexterity, but it makes it impossible for a right-handed navigator to pick up a pencil and record the reading of his sextant without first putting the instrument down. Navigators of surface vessels overcame this difficulty by employing an assistant to record their observations; an expedient which is impracticable, if not impossible, in an airplane. Therefore, when progressive navigators, such as Weems, took up the problem of applying nautical astronomy to aerial navigation, they developed sextants that are held in the left hand and operated by the right one which is available for

making notes when not actually manipulating the controls of the instrument.

The operators of such widely differing devices as sextants, typewriters, and pipe organs have, however, one thing in common. They work almost exclusively by sense of touch in accordance with directions obtained visually from a conveniently located source. The design of the control mechanisms of such devices, therefore, resolves itself fundamentally into the problem of arranging the necessary knobs, keys, and stops in such a way that all may be reached readily. Those more frequently used should, of course, be in positions accessible for operation by the more easily trained, and therefore more capable, hands or fingers.

The design of the control and instrument panel of an airplane is essentially a more complex problem involving not only the convenient arrangement of the control gear, but also the co-ordination of this gear with the arrangement of the means by which the operator receives essential information. For the pilot of a plane obtains information not only visually, but also by sound and by the feel of the controls. Furthermore, some of the information obtained visually is, under normal conditions, secured from outside the plane through the cockpit windshield and windows, while some comes from gauges and dials mounted on the instrument panel. But the onset of instrument weather denies the pilot practically all information obtained visually through the cockpit windows and requires him to substitute for it additional information secured from the instrument panel. This at once confronts the designer with the necessity of so arranging a large number of instruments that the pilot can see them effectively out of the corner of his eye while he is either looking ahead through the cockpit windows or has his eyes focused primarily on the artificial horizon and other items of equipment used in blind flying. Then, too, the various control levers, buttons, and handles must be arranged so that essential ones can be readily reached by both the pilot and copilot and all of them can be manipulated by the two men working as a team. At the same time there may be no wide deviations from arrangements of control gear and instruments that have been accepted as more or less standard.

Research at Sands Point has shown that the first step in the solution of such a problem is to decide upon what items of information are really necessary to the operator and to eliminate gauges and dials that, by giving non-essential information, tend to confuse rather than assist him. That such an obvious conclusion has not been generally appreciated in the past is surprising, but nevertheless true. The next step is to arrange essential instruments so that a quick glance will tell the operator whether or not "all's well." It is rarely necessary for a pilot to know the exact readings of pressure gauges, ammeters and voltmeters, but it is vital that he be able to tell at a glance whether or not the readings of a number of such instruments are within the upper and lower limits of safety. This may be achieved by arranging dial gauges so that their most desirable readings are indicated by some easily recognized position of the pointers, such as vertical, and that trouble or danger is indicated on all gauges by some easily recognized angle with the vertical, such as 45 degrees. An arrangement that has (*Concluded on page 276*)



Special Devices Division, Bureau of Aeronautics

A student officer at Sands Point solving problems of navigating a large plane on a long flight. The instruments he uses and the conditions under which he works closely simulate those actually experienced in a patrol plane making an overseas reconnaissance.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Campaign Oratory

BALLOTS will soon be mailed to members of the Alumni Association of M.I.T. to elect new officers and representatives of the Association. Nominee for the presidency of the Association for the coming year, to be elected this spring, is C. George Dandrow, '22, IX-B, Vice-president and General Sales Manager, Industrial Products Division, Johns-Manville Sales Corporation, New York City.

The National Nominating Committee — consisting of Robert S. Williams, '02, chairman, Ralph C. Robinson, '01, Fred W. Morrill, '07, Gordon G. Holbrook, '10, Irving W. Wilson, '11, Jonathan A. Noyes, '12, Robert C. Erb, '17, Charles A. Williams, '21, Henry C. Gunning, '26, and Stephen L. Macdonald, '39 — has also nominated Orville B. Denison, '11, VI, Chamber of Commerce, Gardner, Mass., to serve as vice-president for two years. Nominees for election to posts on the Executive Committee for two-year terms are: Allen Latham, Jr., '30, II, Arthur D. Little, Inc., Cambridge, Mass., and Hugh S. Ferguson, '23, XV, Dewey and Almy Chemical Company, Cambridge.

Named for alumni term membership on the Corporation of the Institute to serve for five years are: Raymond H. Blanchard, '17, X, Vice-president and Director of the Hood Rubber Company, Watertown, Mass.; Thomas D'A. Brophy, '16, IV, President, Kenyon and Eckhardt, Inc., New York City; and Thomas H. West, 3d, '22, II, President, Draper Corporation, Hopedale, Mass.

New representatives on the National Nominating Committee to be elected this year (one from each district) are: *District 3* — Springfield Club, Minot R. Edwards, '22, XV; Pittsfield Club, Harry Kalker, '23, I; *District 6* — Washington Club, Aubrey D. Beidelman, '15, XIII; Richmond Club, John S. Williams, Jr., '22, XV; Charleston Club, Irvin L. Murray, '26; *District 7* — Indianapolis Club, Thomas G. Harvey, '28, III; Duluth Club, Arthur C. Josephs, '28, I; Louisville Club, Elmer A. Skonberg, '29, XV.

FOR PRESIDENT

. . . of the Alumni Association, C. George Dandrow, '22, IX-B, has been nominated for election for the coming year. Mr. Dandrow prepared for M.I.T. at the Boston English High School and after graduating from the Institute was employed by the Johns-Manville Sales Corporation in Boston. After five years he transferred to the general engineering staff at the company's headquarters in New York. In 1930 he was named staff manager to handle the company's products for pulp, paper, lumber, and the textile industries. In 1931 he was promoted to sales manager, and in 1936 he became New York district manager. He became vice-president and general sales manager, Industrial Products Division, on January 1, 1946. In 1947 Mr. Dandrow was elected to serve as alumni term member of the M.I.T. Corporation for a five-year period. He is serving as vice-president of the Alumni Association for the term 1946–1948. Mr. Dandrow has taken an active part in the activities of The M.I.T. Club of New York, and served as president from 1941 to 1946. In his professional field, Mr. Dandrow is a member of the American Society of Civil Engineers and also of the Engineers' Club of New York City. He is director of Junior Achievement, Inc. of New York, and treasurer and director of New York Building Congress.

Nuclear Science Administrator

MALCOLM M. HUBBARD, '29, has been appointed assistant director of the M.I.T. Laboratory for Nuclear Science and Engineering and will be responsible for administration, personnel, and supervision of design and engineering in the central shops. He will also supervise several experimental projects, according to a recent announcement by James R. Killian, Jr. '26, Vice-president of the Institute.

Mr. Hubbard was graduated from M.I.T. in 1929 with the degree of bachelor of science in electrical engineering. From 1929 to 1941 he was a member of the engineering staff of the Bell Telephone System, serving principally in New England. From 1933 to 1934 he was power supervisor of the Western Division of the New England Telephone and Telegraph Company.

In 1941 Mr. Hubbard was appointed a research associate in the Radiation Laboratory of M.I.T., and in 1942 he was made a group leader in the component engineering division. In 1945 he became associate head of the transmitter components division. He was then appointed to the Instrumentation Laboratory of the Institute, serving until 1946 when he joined the staff of the Laboratory for Nuclear Science and Engineering.

Mr. Hubbard is a member of the nucleonic committee of the American Institute of Electrical Engineers, and also a member of a similar committee of the Institute of Radio Engineers.

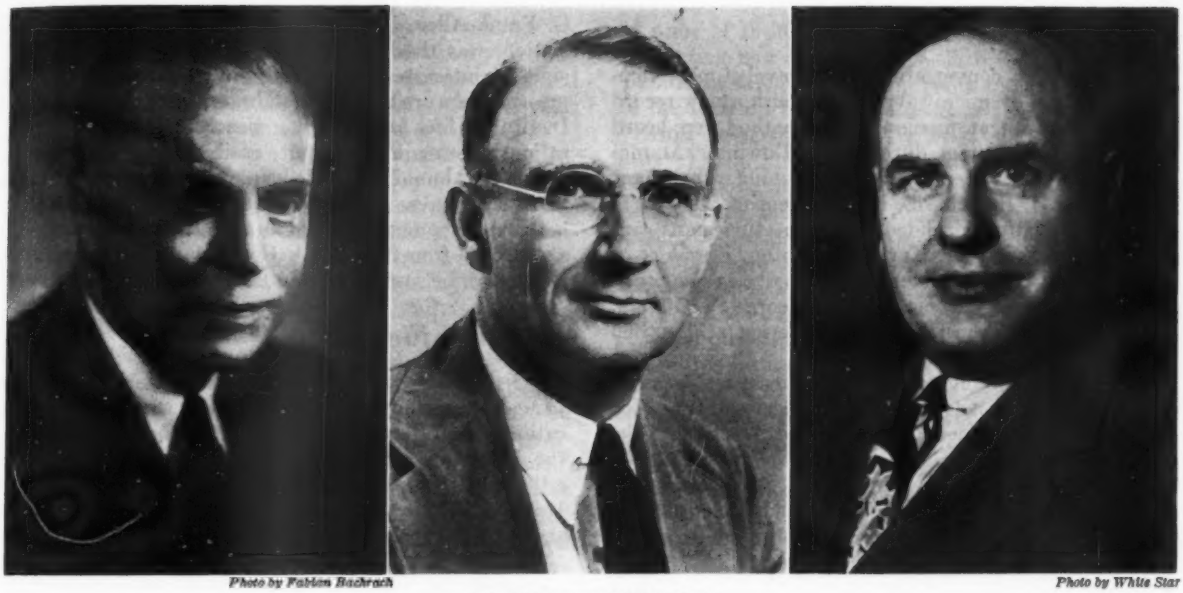


Photo by Fabian Bachrach — Photo by White Star

TO THE CORPORATION

. . . for a five-year term, as representatives of the Alumni Association, the National Nominating Committee has selected (left to right): *Thomas D'A. Brophy, '16, IV, President of Kenyon and Eckhardt, Inc., New York City; Thomas H. West, 3d, '22, II, President of the Draper Corporation, Hopedale, Mass.; and Raymond H. Blanchard, '17, X, Vice-president in charge of manufacturing and Director of the Hood Rubber Company, Watertown, Mass.*

K.T.C., C.B.E.

IN his recent appointment as an honorary commander of the civil division of the Order of the British Empire, President Karl T. Compton has received one of the highest honors the King can bestow on a civilian for extraordinary service. The honor was transmitted to Dr. Compton by Lord Inverchapel, British Ambassador to the United States, who notified him that King George made the appointment "in recognition of the valuable services . . . rendered to the Allied cause in various fields of scientific research and development."

In World War II, Dr. Compton had a leading role in directing the application of science to the war effort. He was a member of the War Resources Board from 1939 to 1940, and was appointed a member of the National Defense Research Committee of the Office of Scientific Research and Development in 1940, serving through 1945. In 1942 he served on the Baruch Rubber Survey Committee. Dr. Compton was chairman of the Radar Committee of the Joint Committee on New Weapons of the Joint Chiefs of Staff from 1942 to 1945, and he served during the same period on the advisory staff of the Chief of Ordnance Military Training.

In 1943 he went to England as chairman of the United States Radar Mission to the United Kingdom. His wide experience in organizing science for war led to his appointment in 1943 as chief of the Office of Field Service of the Office of Scientific Research and Development, a post which he held until 1945. From 1943 to 1944 he was special representative of Secretary of War in the Southwest Pacific Area, and he served as a member of the advisory board of the Army Specialized Training Division from 1943 to 1946. In 1944 Dr. Compton was appointed to the Committee on Post-War Research and Development of the Secretaries of War and Navy, and from 1945 to 1946 he served on the advisory board of the Research and Development Branch of the Office of the Quartermaster General. He also served in 1945 on the advisory board of the Chemical Warfare Service and was a member of the Secretary of War's Special Advisory Committee on the Atomic Bomb.

In 1946 he was appointed by President Truman to be a member of the President's personal committee on the atomic bomb test, and he was also appointed a member of the Joint Chiefs of Staff Evaluation Board on the Atomic Bomb Tests, and more recently to membership on the Advisory Commission on Military Training. In 1945 Dr. Compton served as a director of the Pacific Branch of the Office of Scientific Research and Development and during that period was a member of the Scientific Intelligence Mission to Japan. He is also a member of the Naval Research Advisory Committee.

New Alumni

APPROXIMATELY 380 students received their degrees at commencement exercises held in Walker Memorial on the afternoon of February 4.

Commencement ceremonies for the Class of 2–48 began at 3:30 P.M. with an organ recital by Samuel Walter. The invocation was given by Everett M. Baker, Dean of Students. Diplomas were presented to the graduates by Karl T. Compton, President of the Institute, and John W. M. Bunker, Dean of the Graduate School.

The Review is pleased to publish (page 266) President Compton's address to the graduates "Food, Fuel, and Faith," and to welcome the graduates as new additions to the Alumni Association of M.I.T. Upon conclusion of the commencement exercises a president's reception for graduates and their relatives was held in Morss Hall.

Talking Turkey

TELEPHONE conversations that traveled more than 5,000 miles by microwaves to establish a new record for long-distance transmission by this method were heard by 800 M.I.T. Alumni during the Midwinter Alumni Meeting in Walker Memorial on the evening of February 7. Raymond H. Blanchard, '17, President of the M.I.T. Alumni Association, presided at the meeting and introduced the speakers: Dr. Karl T. Compton, President of the Institute; H. E. Lobdell, '17, Executive Vice-president of the Alumni Association; and George W. Gilman, '23, Director of Transmission Engineering at the Bell Telephone Laboratories in New York.

The record-breaking telephone conversation was the climax of a demonstration by engineers of the Bell Telephone Laboratories, as well as the American Telephone and Telegraph Company and the New England Telephone and Telegraph Company, of various types of long-distance radio telephone calls, which included communications with a vessel at sea, an automobile, and to Honolulu, Nantucket Island, and a ranch in a remote section of Colorado, near Cheyenne Wells.

In the unusual long-distance microwave call the voice of Paul W. Blye, '19, a member of the staff of the Bell Telephone Laboratories, made 12 round trips on the microwave circuit between Boston and New York. The distance of approximately 5,280 miles thus traversed is equal to that between Boston and Istanbul, Turkey. Many of the Alumni who witnessed the microwave demonstration recalled that 32 years ago, when the Institute moved to its new buildings in Cambridge, J. J. Carty, then chief engineer of the American Telephone and Telegraph Company, arranged long-distance calls to various parts of the American continent, a spectacular demonstration which came only a year after the establishment of coast-to-coast telephone service.

Mr. Gilman opened the demonstration by reproducing a telephone conversation typical of a transcontinental call 30 years ago, a striking contrast with the reproduction of a conversation by modern telephone transmission. Speaking of the early days of radio as an adjunct to wire telephony, Mr. Gilman recalled that in 1915 speech was transmitted for the first time in history by radio across the Atlantic to Paris, as well as across the continent to California and well out into the Pacific.

Demonstrating the effectiveness of modern transmission by wire and radio circuit, Mr. Gilman arranged conversation between Dr. Compton and Dr. Gregg Sinclair, President of the University of Hawaii in Honolulu. The voices were amplified so that the audience could clearly hear the conversation.

Experiments which have led to the establishment of telephone service with automobiles began in Boston in 1934 when a group of Bell Telephone engineers began a comprehensive study of communication by radio at high frequencies with automobiles. At present telephone service to automobiles is being given in nearly 70 cities and towns in the country and nearly 5,000 automobiles can be reached from any telephone, a fact which was quickly demonstrated by a call to a car traveling near Springfield, Mass.

Prior to the telephone demonstration, Mr. Lobdell spoke on the origin and growth of the Alumni Association of M.I.T. In his address he observed that Professor C. Frank Allen, '72, one of the originators of the Association, was the second oldest living alumnus and still actively interested in Institute and alumni matters. At present there are 86 alumni clubs, one for each year of the Institute's life, and it is confidently expected that this ratio can be maintained quite easily.

Boston Alumni also had the pleasure of hearing a summary of progress on some of the current projects for the better development of facilities and educational programs at M.I.T. from President Compton. Dr. Compton's report will be summarized in the April issue.

Rockwell Field House

TO meet the increasing needs and demands in intercollegiate and intramural athletics and physical education at M.I.T., a new field house will be constructed on the Institute's property west of Massachusetts Avenue adjacent to Vassar Street. It will be built near the present Briggs Field House, to which it will be connected. Construction is expected to begin this spring.

The new field house will be named for Dr. John A. Rockwell, '96, who was, until recently, chairman of the Advisory Council on Athletics. The structure will be 200 feet long and 165 feet wide, and hence comparable in size to most buildings of its type in the East.

Plans for the new building call for a partial glass wall 30 feet high with a roof span which will provide natural lighting facilities, an incorporated equipment room, and an additional locker space. Below the glass section the wall of the building will be constructed of cinder concrete blocks. A floor will be made up of a mixture of clay, peat moss, and sand, which is standard for this type of sports facility. The plans for the building are in charge of the firm of Anderson and Beckwith, designers of Technology's Alumni Pool and other buildings on the Institute's campus.

The Rockwell Field House will provide much needed indoor facilities for practicing and competition in the 16 different intercollegiate sports in which M.I.T. students engage. The building will house a one-twelfth of a mile standard indoor cinder track, jumping and vaulting pits, and a space large enough for indoor practice at various times in lacrosse, soccer, football, golf, soft ball, badminton, and tennis. A cage for baseball practice is also included in the original plans to meet the demands for facilities when this sport is instituted.

Dr. John A. Rockwell, for whom the new field house will be named, has been actively interested in athletic affairs at the Institute since 1898 when he was elected a member of the Advisory Council on Athletics. He served more than 50 years on this Council and was its chairman from 1914 until last November when the new Athletic Board was created at the suggestion of the Advisory Council on Athletics.

Of Ships—and Many Things

ALUMNI Council meeting, number 260, was held in the Campus Room of the Graduate House on the evening of January 26, 1948. Raymond H. Blanchard, '17, President of the Association, presided over the 89 members and guests assembled. Among the guests was the Honorable Charles Francis Adams, former Secretary of the Navy.

Charles E Locke, '96, in his customary manner reported that 11 Faculty and staff members had visited 19 alumni clubs during December and January, announced changes in class affiliation for five students, and presented the slate of new officers for the Alumni Association.

A report was read from William W. Garth, Jr., '36, general chairman, naming Alumni Day subcommittee chairmen as follows: *Banquet:* Edmund B. Fritz, '32; *Class Day:* John A. Hrones, '34; *Exhibits:* Herbert L. Beckwith, '26; *Ladies' Program:* Mrs. B. Alden Thresher; *Luncheon:* John B. Wilbur, '26; *Publicity:* Ralph T. Jope, 28; *Registration:* Wolcott A. Hokanson, Staff; *Symposium:* Norman J. Padelford, Staff; *Symposium Arrangements:* Donald Whiston, '32; *Transportation and Hotel Accommodations:* Malcolm S. Stevens, '34; *Ways and Means:* Delbert L. Rhind, Staff. Alumni Day will be held on Saturday, June 12, 1948, and the theme for the symposium and other activities will be "Logistics of Peace."

The Council voted to elect the above subcommittee chairmen and to approve the eight candidates proposed by the National Nominating Committee. It also elected members to two new advisory councils: one on Undergraduate Government, with Marshall B. Dalton, '15, as chairman; and the other on Tech Show, with Edwin D. Ryer, '20, as chairman.

During the business portion of the meeting the following reports were rendered: Parke D. Appel, '22, as chairman of Alumni Day, June, 1947, summarized the events of the last and most successful Alumni Day. Henry B. Kane, '24, Director of the Alumni Fund, stated that the Fund had reached $200,000 and, with three months to go this year's contributions already exceeded those of last year by $15,000. Robert C. Casselman, '39, chairman of the Committee on Assemblies, announced that arrangements for the Midwinter Meeting of Alumni in Metropolitan Boston had been completed. Stanley G. H. Fitch, '00, presented the report of the Committee on Resolutions for the late C. Burton Cotting, '00, which was accepted by silently rising.

Mr. Blanchard then introduced James R. Killian, Jr., '26, Vice-president of M.I.T., who presented a summary of some of the latest developments at the Institute by recounting how his day had been spent. A considerable amount of attention is being given to the optimum size of the Institute's stabilized postwar student enrollment.

After being introduced by President Blanchard, Admiral Edward L. Cochrane, '20, Professor of Naval Construction, in charge of the Department of Naval Architecture and Marine Engineering, spoke on "The Future of Naval Construction and Merchant Shipping." He referred graciously to his earlier work under the Honorable Charles Francis Adams, former Secretary of the Navy, when he made studies for the Navy on the value of welding in shipbuilding. Although it is vain to speculate on the future, Admiral Cochrane believes there is as much need as ever for a modern Navy as well as for a merchant marine, and that the manner in which aviation and shipping supplement, as well as compete with, each other will provide substantial benefits for the nation. The war has made serious inroads in our mineral resources, and ships, rather than planes, will be needed for import of mineral ores. Higher operating and labor costs are having a marked influence on ship designs; whereas ships of 3,000 to 4,000 tons and running at about eight knots were typical during World War I, today's ships are more likely to be about four or five times that tonnage and operate at speeds of 15 knots or even more. The speed of such ships has made it profitable to bring ore from Chile, even though no cargo could be carried on the return trip. Admiral Cochrane believes that the United States needs more large passenger ships, not alone for the normal passenger traffic they carry in times of peace but also as a measure of national security. United States shipbuilding yards also need construction work sufficient in amount to maintain a well-trained group of shipbuilders who can serve as a nucleus to train green labor when the need for rapid expansion arises. As has always been the case, the Navy will provide an important line of defense. With recent developments in aircraft and in submarines which might attempt to attack this country's shores, the most effective defense will require changes in the design of capital ships.

Radio, as a medium of adult education, earned some very good marks from the presidents and a dean of six of New England's leading colleges and universities in the Boston area on a special broadcast on the evening of February 1, the first anniversary of the Lowell Institute Co-operative Broadcasting Council.

Participating in the broadcast were (seated, left to right): *Daniel L. Marsh, President of Boston University; Karl T. Compton, President of M.I.T.; Leonard Carmichael, President of Tufts College; Carl S. Ell, '11, President of Northeastern University; and James Bryant Conant, President of Harvard University.* (*Standing*): *Ralph Lowell, Trustee of the Lowell Institute; and Reverend Stephen A. Mulcahy, Dean of Boston College, speaking for the Very Reverend William L. Keleher, President of that institution, who was ill. It was the first time that all these noted New England educators were presented together on a radio program.*

Nucleonic News

ATOMIC research and training of nuclear scientists will be advanced through a $250,000 grant which has been made to M.I.T. by The Texas Company. In announcing the grant Dr. Karl T. Compton, President of the Institute, and Colonel Harry T. Klein, President of The Texas Company, indicated that the funds will be used for long-range pure research in nuclear fission and related basic studies on the ultimate nature of matter and energy. They will also be used to construct high-voltage equipment of advanced design, and to train scientists in nuclear theory and its application.

This work will be carried on primarily in the Laboratory for Nuclear Science and Engineering, which will co-ordinate its efforts with the Departments of Physics, Chemistry, Chemical, Electrical, and Mechanical Engineering, Metallurgy, and Biology, for maximum interchange of information.

Investigations already under way in the laboratory have revealed that cosmic rays, nature's source of particles of highest energy, are composed of less than one per cent free electrons, contrary to former scientific belief. The newly acquired knowledge that cosmic rays are principally protons is another fact in the unexplored field of nucleonics which may lead to vast practical applications.

In another direction, new hope for sufferers from certain diseases is offered by experiments in physical medicine that employ extremely high-voltage, short-wave x-rays.

Emphasizing the importance of nuclear research extending knowledge gained through intensive research during World War II, Dr. Compton said:

> In this far-reaching investigation of nuclear processes we will cross scientific frontiers into new territories of which only a small part has been explored. The discovery of that particle of matter, the electron, led to the creation of the great industry of radio and allied methods of communication. There is every reason to believe that equally exciting and important discoveries will come from a better understanding of the structure of matter. In such fundamental research we cannot always foresee what discoveries may be ahead, but no investigations on such a scale have ever failed to produce knowledge of enormous value.
>
> This grant from The Texas Company is an outstanding example of the ever widening range of industrial interest in the advancement of fundamental knowledge. It constitutes an enlightened form of investment in progress, contributing not only to the development of new processes and new products, but to the education of young scientists and engineers.

Explaining The Texas Company's interest in nuclear research, Colonel Klein said:

> It is the hope of The Texas Company that this grant will help science usher in a new era of technological progress through a greater knowledge of the atom. In terms of new products and machines, such basic research cannot be expected to bear fruit commercially for many years to come. But the investigations carried forward in the Laboratory for Nuclear Science and Engineering at M.I.T. hold promise of discoveries that may revolutionize our approach to technical problems both in science and in industry.
>
> Since industry will eventually pass on to humanity the benefits of this work, it is to its own interest, as well as mankind's, that it take the lead in making basic research possible.

The tools of science which will be used in this project include the Institute's cyclotron and two electrostatic generators with capacities up to 4,000,000 volts which are already in operation. Future developments call for still larger instruments, including a 300,000,000-electron volt synchrotron, now in the process of construction, and a 12,000,000-volt electrostatic generator.

One division of the investigation will concentrate on studies of nuclear theory, nuclear chemistry and other problems bearing on a better understanding of nuclear structures and forces, and of the fission process.

One important phase of the program is the training of competent nuclear scientists and engineers by allowing them to conduct pioneer studies and thus gain invaluable firsthand experience. As future teachers and industrial researchers, the information and techniques they acquire on the project will contribute substantially to scientific knowledge in schools and industry.

Through its main objective of arriving at a better understanding of the nature of the nucleus, the program is also expected to make substantial, if indirect, contributions to engineering and industrial applications of atomic energy.

Francis M. Currier: 1895-1948

FOR many years a member of the Faculty of the Department of Modern Languages at M.I.T., Francis Morton Currier, Associate Professor of German, died on February 11, following an illness of several months. He is survived by his wife, the former Margaret W. Chase, whom he married in 1927.

Professor Currier was the son of the late Professor Charles Francis Adams Currier, who was head of the Department of History at M.I.T. from 1907 until his retirement in 1918.

Born in Somerville, Mass., on July 30, 1895, Professor Currier was graduated from the Winchester High School and then entered Harvard, where he was graduated with the degree of bachelor of arts in 1917. Continuing his studies he was awarded the degree of master of arts in 1921 and doctor of philosophy in 1936. He was graduated *magna cum laude* with honors in German.

He began his teaching career at M.I.T. in 1918 as instructor in modern languages. The following year he joined the staff of the Middlesex School where he was an instructor from 1919 to 1922. He was then appointed master in the St. Alban's School, Washington, D. C., and served from 1922 to 1928. Returning to the Institute in 1928 as an instructor in German, Professor Currier served continuously until recently. He was appointed assistant professor in 1939 and advanced to the rank of associate professor in 1945.

During his academic career, Professor Currier traveled widely in England, Scotland, Belgium, Holland, France, Germany, and Switzerland, carrying on advanced research in university and European libraries, particularly in Breslau, Dresden, and Munich.

He was a former president of the Boston chapter of the American Association of Teachers of German, and a member of the Modern Language Association of America, the New England Modern Language Association, and the American Association of University Professors. He had contributed many papers on problems and techniques of teaching languages.

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PSYCHOLOGY, MEN, AND MACHINES

(Concluded from page 269)

been suggested as even more effective would be to substitute for the familiar circular dials of the instrument board, horizontal rows of rectangular frames behind which horizontal hands of light move up and down on semitransparent calibrated scales. It would then be possible to proportion the various scales so that optimum readings for a given condition are indicated by the horizontal bands of light on the various calibrations lining up across the entire instrument panel opposite the designated operating condition.

All these problems are ones in which the specialist in what has recently been called "human engineering," but might more accurately be termed physiological psychology, can be of the greatest assistance to the designing engineer. For more than a century, the psychologist has been studying the reaction of the human mind and body to the messages given it by the senses. He has at his command a wealth of information as to the limitations and capabilities of the mind and the organs through which it gathers information, principally the eyes and ears. The psychologist can therefore advise as to what arrangement of an instrument board will display information to the operator in a manner that is clear, unambiguous, and compelling. Finally, he has much information at his disposal as to limitations and capabilities of the body to respond to information obtained by sight and hearing. If a gauge, dial, signal light, or bell warns an operator of the necessity of a certain action, in what fraction of a second may he be expected to move the levers or valves that demand his attention, and how will this time interval be affected by the position and character of the controls which must be moved?

But suppose that the design of an unusual control mechanism poses questions that the psychologist cannot answer from his own knowledge or that of his contemporaries and predecessors? He is then in a position to advise as to the methods or research which will probably yield the desired information with a minimum expenditure.

At Sands Point the psychologist is a true partner of the engineer, for not only is he assisting the designing engineer to improve the layout and effectiveness of control gear, but he is also helping the operating engineer to develop methods and procedures which improve the efficiency with which existing types of control gear are used. For example, it has been found that rearrangement of the items on some of the checkoff lists used by the pilots and copilots of large planes preparatory to a take-off or landing can materially shorten the time required to make the necessary checks, and at the same time reduce errors.

Finally human engineering is teaming up with medicine to study and determine the effect on the body and mind of the pressure and temperature changes and the accelerations to which a pilot will be subjected when he flies in proposed types of aircraft designed to travel at supersonic speeds. To this end, the specialists at Sands Point are directing the engineers and scientists designing and building the human centrifuge at Johnsville, Pa. This huge piece of laboratory equipment should enable man to appreciably extend his knowledge of the capabilities and limitations of his own body and mind.

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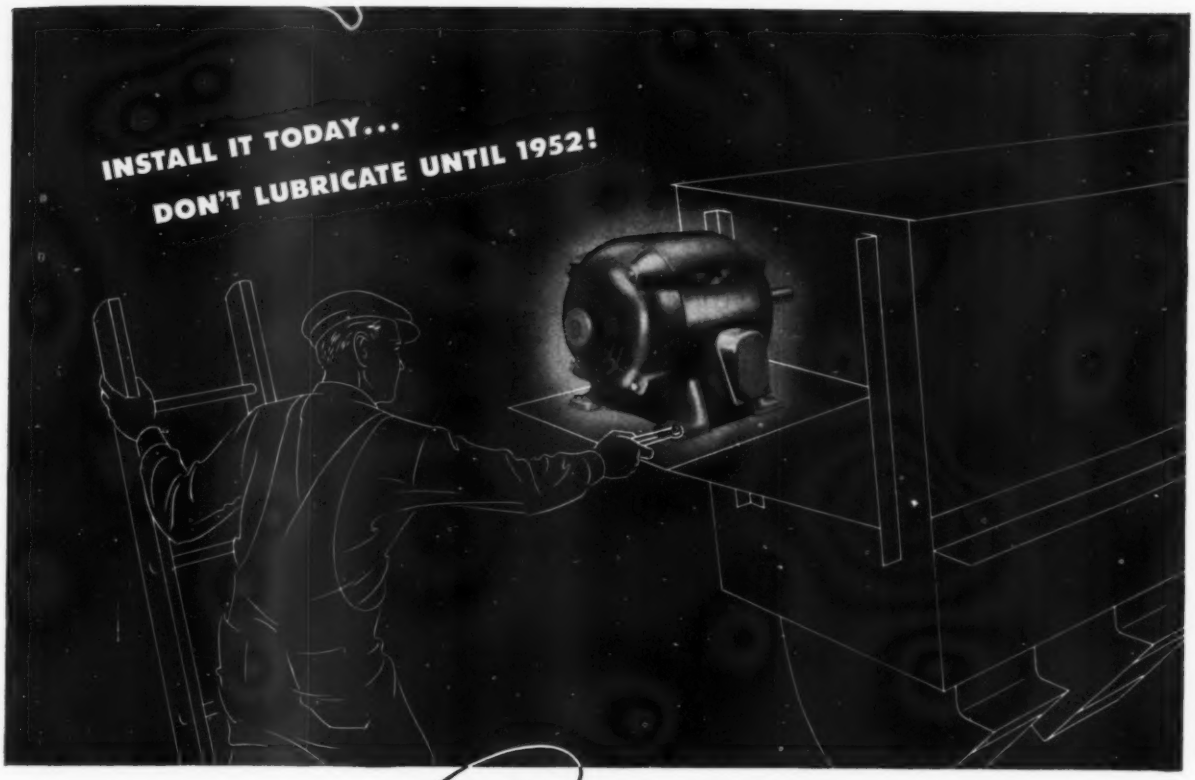

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ROAD TO FORTUNE

(*Continued from page 265*)

stop to fight off the day's Indian attack, and then resume their grading or track-laying. As construction superintendent, General Casement had to produce a finished railroad that would cross the Nebraska plains, make the steep rise through the Black Hills to the Laramie Plains, and then follow the tortuous although less steep passage through the Rocky Mountains, thence continue to the Great Salt Lake. Matching the ingenuity of Judah in selecting his Donner Lake Route for the Central Pacific, was the determination of General Dodge to explore a practical crossing over the Black Hills for the Union Pacific. Accidentally, while fleeing an Indian attack, he finally found it, and named this highest point in the Union Pacific "Sherman" in honor of his Civil War commander.

At an average rise of six feet per mile across Nebraska, the initial section of the Union Pacific Railroad does not compare in interest with that of the Central Pacific, with its rise of about 7,000 feet in the first 100 miles. The Union Pacific had more distance to cover, however, and in its mountain sections encountered difficulties like those of its western rival, the Central Pacific. When the advance parties of the two railroads began to parallel each other, Congress decided the two lines should meet — at Promontory Point, near Ogden, Utah.

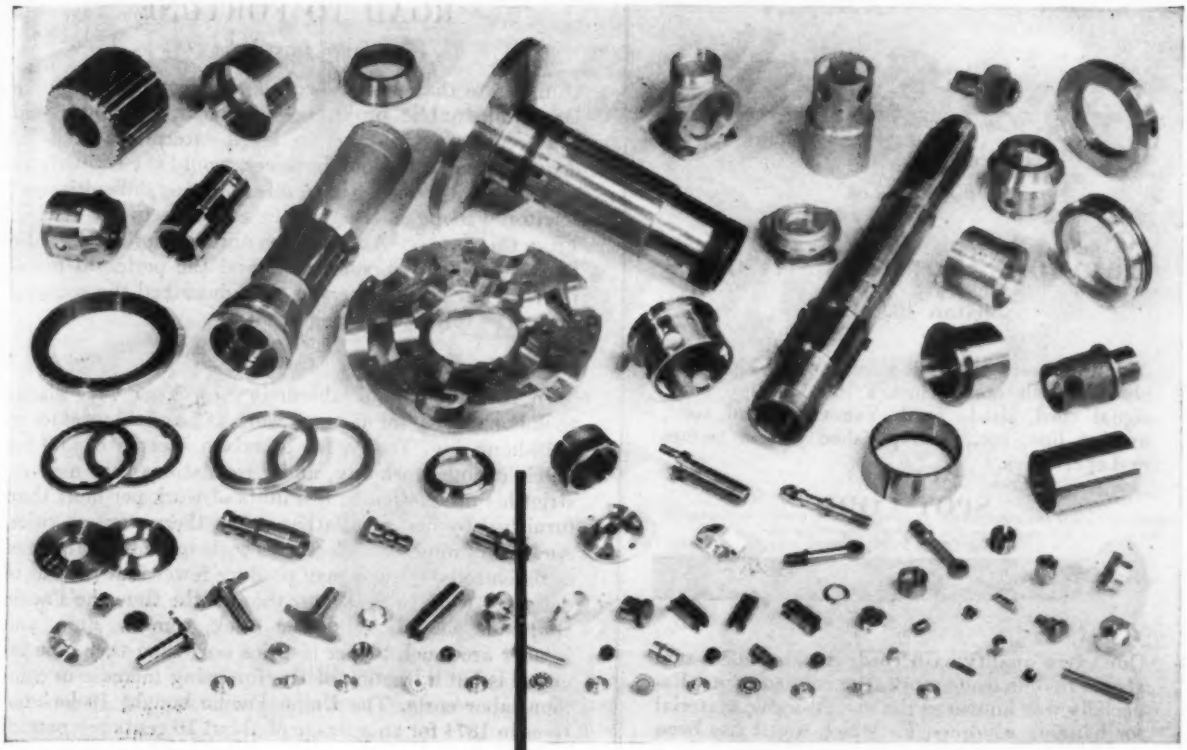
Melodrama of 1869

All America went wild upon the completion of the Pacific Railroads on May 10, 1869. This is only a slight overstatement. "Hysteria" and "deification of the railroads" are terms which unfriendly historians applied to the prevailing public sentiment, as they wrote later, in the ensuing period of bitter antirailroad feeling. While ambitious farmers and artisans of the East dreamed of the opportunities for the poor man in the Great West, now made accessible, bankers saw huge profits in the deposits of gold, silver, and lead, now so easily reached by the great transcontinental railroad. Even the staid *Atlantic Monthly* waxed enthusiastic, and shrewd John August Roebling, promoting his Brooklyn Bridge, said that the bridge was now essential to New York City.

While the blow-by-blow telegraphic description of the "last spike" ceremonies approximated a modern radio broadcast, it is hard to recall any modern peacetime exhibition of such exuberant rejoicing throughout the nation. By direct electrical connections with Promontory, or on signal, noisemakers of all sorts were set off, in San Francisco, Sacramento, Omaha, Chicago, Washington, New York, Boston, New Orleans, and points between. The fire bells of cities rang; parks of artillery barked in salute, streets were illuminated, and ships in harbors were gaily dressed. Thirty locomotives in Sacramento shrieked all at once, and the Liberty Bell rang in Independence Hall, Philadelphia. There were processions of horse-drawn floats, fraternal bodies, batteries and bands. A long line of mail wagons bore bags labeled with such destinations as Hong Kong, Australia, and Yokohama.

Of deep significance to the engineering profession was the demonstration of its ability to construct an engineering enterprise of unprecedented scope to meet an acutely urgent public demand. From thenceforth, the American

(*Continued on page 280*)



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ROAD TO FORTUNE

(*Continued from page 278*)

triumvirate that was to become so effective in building large-scale public projects — politician, promoter, and engineer — was to take up large enterprises with increasing tempo. Seldom, however, would the triumvirate tackle a project of such unusual organizing difficulties and territorial scope as those of the railroads to the Pacific. From this date on, America was united from the Atlantic to the Pacific. We can understand the perfervid metaphors of our grandfathers as they described the consummation of this outstanding event.

Cost

In 1874 a common laborer in New York City gladly took home $1.40 for as much work as he could produce in a 10-hour day. Today, his grandson accepts $12.00 for an eight-hour work day, under regulations that may restrict his production to less units of work per hour than furnished by his grandfather, when there were no rules. An hour of muscular effort thus costs more than 10 times as much today — and may produce fewer foot-pounds of delivered work in that hour than at the time the Pacific Railroads were built. While brick, cement, lime, and lumber are much higher in price now than then, the increase is but a fraction of the foregoing increase in common labor costs. The Union Pacific bought 10 locomotives in 1874 for an average of about 16 cents per pound; in 1941 the price of locomotives ranged from 25.6 cents to 34.6 cents per pound. But structural steel is cheaper today than in 1879 and steel rails sell at about one half their 1870 price.

To transform to today's price level the dollars spent on the Pacific Railroads during and after the Civil War would require an exhaustive study. The determination of the reproduction cost of this railroad, as compared with its historical cost, would require an evaluation of the foregoing cost trends, up and down, and would have to consider the increased efficiency of today's power equipment as compared with the manual methods then used.

The estimate of the War Department for the proposed route near the 41st and 42d parallels, a few degrees north of the line as built, was $116,095,000, an amount that exceeded the national debt in 1857, when this Report was issued. When the railroads were finished, Poor's *Manual of Railroads* gave the cost as follows:

Union Pacific	$90,000,000
Central Pacific	$60,000,000
Total	$150,000,000

The Pacific Railroads' project was therefore one of the most expensive single public construction enterprises ever undertaken in America.[5]

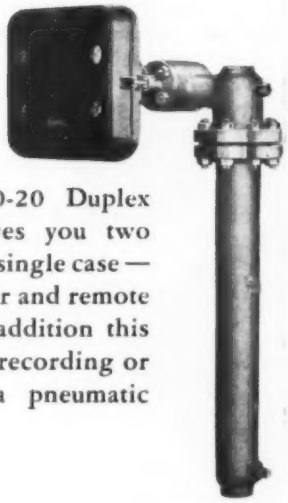
Epilogue

The railroads were now presumably finished, but much remained to be done to make them a going concern. The mild complaint of the railroad commissioners at the huge

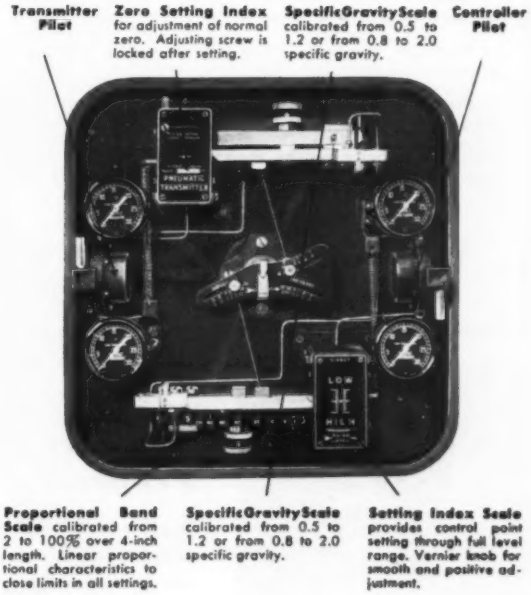
(*Continued on page 282*)

[5] The ultimate cost of the Hoover (Boulder) Dam and Power Plant is given as $152,000,000. The Tennessee Valley Authority project had, in 1947, received total appropriations of over $700,000,000, and the cost of the Panama Canal was given at about $526,000,000 a year after its official opening in 1920.

LEVEL Controller and Transmitter in ONE unit!



Masoneilan Model 12600-20 Duplex Controller-Transmitter gives you two pneumatic mechanisms in a single case — proportional level controller and remote pneumatic transmitter. In addition this arrangement can include a recording or indicating receiver and a pneumatic signal switch.

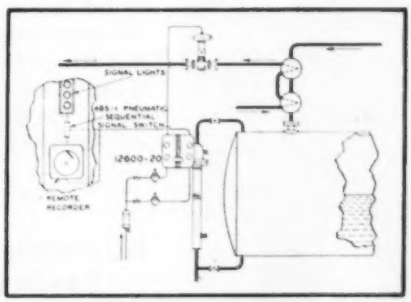

Transmitter Pilot
Zero Setting Index for adjustment of normal zero. Adjusting screw is locked after setting.
Specific Gravity Scale calibrated from 0.5 to 1.2 or from 0.8 to 2.0 specific gravity.
Controller Pilot
Proportional Band Scale calibrated from 2 to 100% over 4-inch length. Linear proportional characteristics to close limits in all settings.
Specific Gravity Scale calibrated from 0.5 to 1.2 or from 0.8 to 2.0 specific gravity.
Setting Index Scale provides control point setting through full level range. Vernier knob for smooth and positive adjustment.

Duplex Controller-Transmitter

The Advantages . . .

1. **Lower original cost.** Control and transmission in a single unit costs less than two individual units.
2. **Lower installation cost.** One installation instead of two. The single unit also saves space, increases accessibility in crowded locations.
3. **Remote transmission** permits location of recording or indicating receiver on a central control panel.
4. **Explosion-proof pneumatic signal switch** provides step by step indication of level or control of related process by actuating signal lights, audible alarms, solenoids, motors or other electrical devices.

Recording receiver



Typical application

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MASON-NEILAN REGULATOR CO.

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Cincinnati • Los Angeles • San Francisco • Mason Regulator Company of Canada, Ltd., Montreal and Toronto

BOSTON INSULATED WIRE B.I.W. & CABLE COMPANY

B. I. W. COAXIAL CABLES TRADE MARK CO-X

B. I. W. offers a complete range of types and sizes of coaxial cable for high frequency applications:

— Small flexible, low capacity (5 to 10 uuf/ft.) for internal wiring, patch cords, etc.

— Coaxial and Twin-axial weatherproof cables for antenna lead-in and other outdoor uses.

— Flexible standard synthetic insulated cables for electronic apparatus.

— Heavy duty, high power, flexible or semi-rigid transmission line.

All of the above can be supplied with special fittings and junctions for connections to panels or rigid lines.

BOSTON INSULATED WIRE AND CABLE COMPANY
BOSTON 25, MASSACHUSETTS

Keeping Step with Progress . . .

Diefendorf engineers share with the designers of "machinery for tomorrow" a desire to build the equipment needed to keep America great—gears of all types—built to specification, all metals and non-metallics.

•

DIEFENDORF GEAR CORPORATION
Syracuse 1, New York

DIEFENDORF GEARS

ROAD TO FORTUNE

(*Continued from page 280*)

amount of the "Deficiencies in Construction" account of the Union Pacific is understandable. The major charge in this account was for replacement of ties, followed by completing ballast, reducing grades, filling trestles, and completing snow structures.

Many miles of track on both the Central Pacific and the Union Pacific had been laid devoid of ballast, which now had to be placed. In its first five years the Union Pacific spent more than $1,000,000 on tie replacement for the cottonwood ties in Nebraska had proved wholly unsuitable. The Central Pacific likewise found that ties, except those laid in alkaline soil, decayed rapidly. The picturesquely tall and long timber trestles of both railroads were soon found to be costly to maintain. In its 1874 report the Union Pacific announced that all the trestles of the road had been filled; the spoil from widened cuts provided the filling material. Three steam shovels, the first noted in the railroad story, were used in this operation.

Almost immediately, replacement of iron rails became necessary, particularly on the steep-graded sections of the Sierras. Both the Union Pacific and the Central Pacific soon decided that all new rails must be of steel, not iron. As in the case of the contemporary Brooklyn Bridge, and other structures, Bessemer and open-hearth steels were taking over. A program of replacement of chair joints with fishplates was instituted by the Union Pacific. The newer joints would provide better alignment and a more solidly continuous rail structure than the chairs that were originally used in many sections. In the starting year (1869) a partial list of rolling stock was as follows:

Equipment	*Union Pacific*	*Central Pacific*
Locomotive engines	149	166
Sleeping cars (palace)	*	13
First-class passenger cars	26	62
Second-class passenger cars	15	35
Baggage, mail, and express cars	18	23
Platform cars	1107	1293
Caboose (which could be used as emigrant cars)	88	

* Sleeping cars not owned by Union Pacific Railroad.

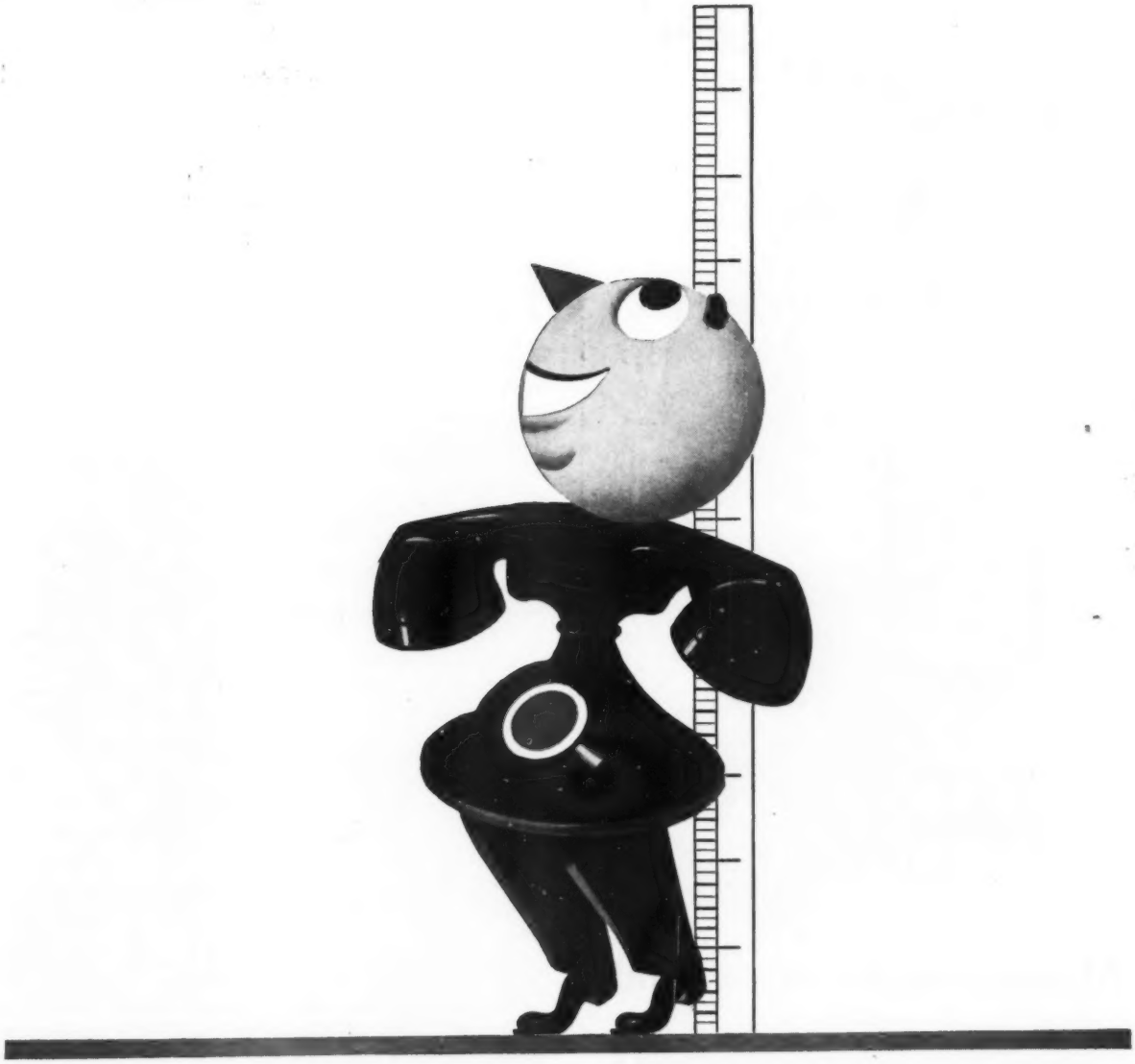
By 1869, the once tiny settlement of Omaha had grown to a city of 16,000 in which were located the machine shops, car works, and foundry of the Union Pacific. At about the same time Sacramento had shops that could build complete locomotives. Soon, the Central Pacific reported that passenger trains had been equipped with the Westinghouse air brakes, although about two decades were to elapse before air brakes were made mandatory.

As to fuel for motive power, the Union Pacific was truly fortunate. It controlled coal mines along its lines. For the year 1875, the wood coal fuel situation of the Union Pacific and Central Pacific can be compared as follows:

Fuel for Motive Power 1875

	Union Pacific	*Central Pacific*
Coal	148,876¾ tons	94,685¾ tons
Wood	7,137 cords	67,399¾ cords
Price:		
Coal	$4.75 per ton	$7.67 (1873)
Wood	6.50 per cord	5.15

(*Continued on page 284*)



A LOT OF GROWING TO DO

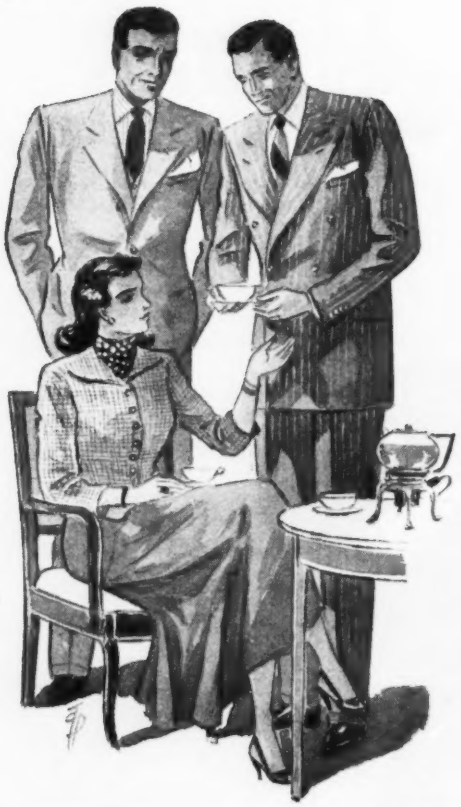
This is a big country and to furnish nation-wide telephone service, the Bell System has had to be big for a long time. But in the last few years it hasn't been nearly big enough.

Even though we've broken all records and added more than 6,000,000 new telephones in the past two years, there are still about a million orders for service that we haven't been able to fill because of lack of equipment, switchboards, cable and buildings. Many more Long Distance circuits also are needed.

It will take time and a lot of money to make the Bell System big enough for the nation's needs but we're on our way —in a big way—to giving you more and better service than ever before.

BELL TELEPHONE SYSTEM

Brains do the fitting!



Measurements only a guide!

Measurements of the human anatomy are only a guide to fit. It takes brains and skilled hands to turn measurements into good-looking clothes—clothes that will *feel right on you* and make you *look your best.*

If you have never worn our kind of clothes we invite you to get to know the *modern* Rogers Peet.

Styles for young men, and men who never grow old.

Rogers Peet Company

Makers of Fine Clothes

In New York: Fifth Avenue *at* 41st Street | Thirteenth St. *at* Broadway | Warren Street *at* Broadway | *And in Boston:* Tremont St. *at* Bromfield St.

ROAD TO FORTUNE

(*Continued from page 282*)

Snow was the great problem for both roads. In fact, throughout all northern America, snow was the white bête-noire of railroads. Snowbound trains were common. During one storm a New Jersey railroad president wired instructions to keep up steam at any cost, to burn fences, to throw in a barn or two if necessary, even to buy pork to burn. After five years of operation, the Union Pacific bragged that its road was no longer liable to serious obstruction by snow, but popular accounts tell of plows driven by as many as 14 engines, and of whole trains lost in the snow storms of the prairies.

Both emigrant and tourist immediately found that the Pacific Railroads traversed pseudo-cosmic distances, and that one had to take account of the travel of the sun, in keeping track of the time. In the year 1883 standard time was adopted by the American Railway Association, the Pacific Railroads operating in the Central, Mountain, and Pacific Time zones.

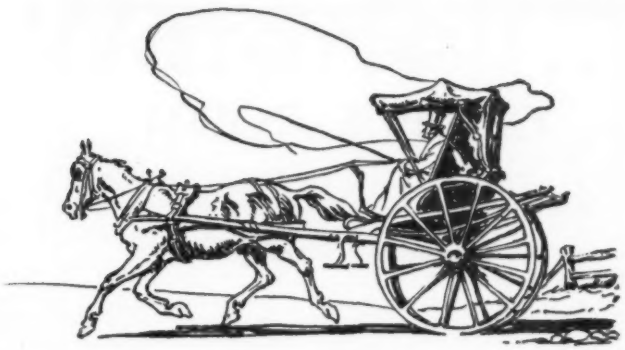
At second-class fare ($75), an emigrant could travel from Omaha to Sacramento in about four days; by wagon train the trip could take 150 days. But the flow of emigrants and tourists was nowhere near the railroads' capacity, despite this opportunity to save money and time and to avoid the deadly hazards of the wagon trail. One daily passenger train and one freight train with cars for emigrants easily handled the traffic which averaged, in one direction, less than 100 through passengers per day in 1871. While the ballyhoo for tourists and emigrants continued, between the melodramatic "last spike" climax and the long, fruitful period of the railroads' splendid part in the civilizing of the Great West, one senses an interlude of anticlimax in the great railroad drama, until one patent factor is considered: capacity. The capacity of one railroad train in passenger-miles per day was equivalent to at least 25 wagon trains each one-quarter of a mile long.

Many a young veteran of the Civil War planned his honeymoon to include a trip across the continent in one of the gorgeously ornate palace cars which guide books portrayed so temptingly. Were he and his bride to return to life and take the same trip today, they would find it much more comfortable and, in comparison, very dull. Marked improvements in roadbed and rolling stock would be apparent. Heavy rails on well-ballasted roadbed would make much smoother riding than the light 50- to 60-pound rails of the 1869 Pacific Railroads. Jolts would be minimized by modern roller bearings. Steam heat would provide more comfort than the hot and cold wood-fired stoves of the era of President Grant. Today's passengers have air-conditioned cars but seven or eight decades back passengers had to swelter in the hot blasts from the prairies of an August Nebraska. Meals in a cool dining car, designed to a balanced diet, would be more tempting than quick gulps of ill-prepared food at eating shacks alongside the tracks.

If the reincarnated veteran of the Civil War is, or was, an engineer, he could honestly say that there have been only minor changes in the basic principles of steam railroad design in the period from the year 1869 to date. He would marvel, however, at the speed and comfort.

But as to the dramatic interest of the trip from Ne-

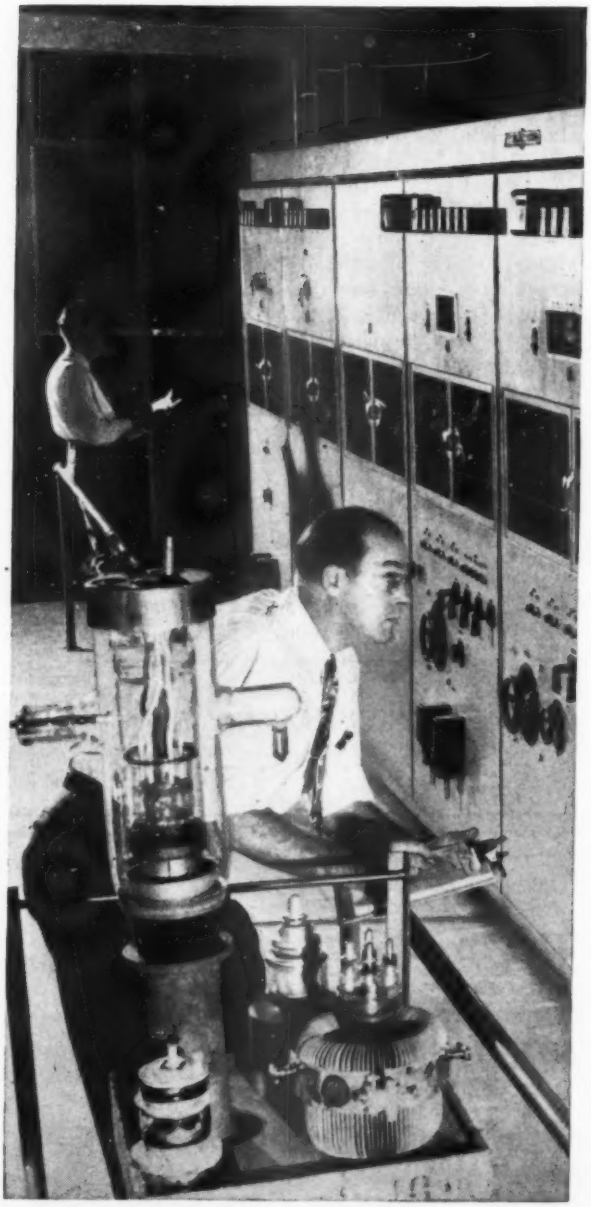
(*Concluded on page 286*)



There was only ONE

wonderful one-hoss shay . . . OR,

WHY G-E ENGINEERS SEEK BETTER "LIFE" TESTS



LIFE-TESTING G-E ELECTRONIC TUBES

"All at once and nothing first,—

Just as bubbles do when they burst . . ."

That is the way the Deacon's Masterpiece—and *only* the Deacon's Masterpiece—went to pieces.

With everything else, failure strikes first at one small part of the whole—at a bearing, a spring, an insulator—many times in the least expected place. "There is always *somewhere* a weakest spot."

The standard method of finding these small points of weakness, as the first step toward correcting them, is the "life" test, in which the product is operated until it breaks down.

Life tests can be standard, perfunctory, routine . . . or, they can be invested with interest, imagination, ingenuity.

In more than a dozen General Electric laboratories today, engineers are making the "life" test work harder, forcing it to reveal more about the quality of parts to be used in G-E products, giving it fresh meaning and new effectiveness.

¶ At Schenectady a newly developed testing device operates G-E switchettes 2200 times a minute, three million times a day—more than they will be operated normally in years of service . . .

¶ At Bridgeport, household fuses must meet tests up to a hundred times as severe as are ever met in use . . .

¶ At Erie an automatic device tests the endurance of refrigerator doors by opening and closing them more times in a few days than the average family does in 25 years . . .

¶ At Syracuse aircraft-radio tubes must function perfectly while a new "vibration machine" shakes them 25 times a second for 100 hours—a much more grueling test than they ever receive in actual flight.

To the engineers the reason for these scientific tortures is obvious: by learning more about every part used by General Electric, they can build G-E products whose performance will not be hampered by minor breakdowns . . . whose useful life can be extended far beyond normal expectations . . . whose service will be long, efficient, faithful. Improved life tests are another reason why . . .

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THE GRADUATE HOUSE
M. I. T.

Cambridge 38, Massachusetts
Tel. Kirkland 2680

ROAD TO FORTUNE

(*Concluded from page 284*)

braska to Sacramento then and now, there would be no comparison. Today our returned veteran of the Civil War would be most interested in whether or not the control of the air conditioning had been set at the right mark.

Three quarters of a century back he might have heard a hoarse voice shout "Indians!" Perhaps such warning would announce a party of Sioux, bent on destruction, or maybe Indians had draped a stolen one-inch rope across the track, a husky brave at each end, to stop the train. Perhaps the voice would shout "buffalo" or "elk" or "antelope." Into tiny ears fair ladies in hoop skirts would insert fingers with unpainted nails, to shut out the sharp roar of rifle or Colt. The poor beasts, whose misfortune it was to have their habitat adjacent to the Union Pacific Railroad were rarely hit. But it would be a glorious trip, and the reincarnated young veteran of the Civil War would probably look back with nostalgia to earlier days.

Stretching tenuously, ever to the West, a thin line appears on an 1870 map of America. It is the Pacific Railroads — the only rail connection to the West Coast. Like the jumbled web of a drunken spider, several transcontinental lines, with scores of branch lines and interconnections, now spread across the map of the western states. The promoters of the Pacific Railroads thus started an orgy of railroad construction, which reached its culmination a few decades later. The agonies of plethora were acute, but the resultant transportation system is still the most important factor in the conveyance of passengers and freight throughout the area once called the American Great West.

Doelcam Corporation

PRECISION INSTRUMENTS

GYROSCOPES — GYROSCOPIC DEVICES

DESIGN • DEVELOPMENT • PRODUCTION

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HAROLD J. RYAN, INC.

Air Conditioning

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Tapping a Waterfall...

TO LIGHT A COUNTRYSIDE... AND A WAY TO SUCCESS!

Design and build a hydro-turbine to meet exacting demands of capacity, head and horsepower . . . that's just one of thousands of absorbing problems tackled and solved by Allis-Chalmers engineers.

A-C probes *every* phase of science and industry—electronics, hydraulics, processing, metallurgy . . . contributes important new machine advancements to almost every basic industry.

What better place could you find to develop your engineering talents! What better chance to grow in your chosen field.

INVESTIGATE

ALLIS-CHALMERS

ONE OF THE BIG 3 IN ELECTRIC POWER EQUIPMENT—BIGGEST OF ALL IN RANGE OF INDUSTRIAL PRODUCTS!

Write for Book No. 6085, outlining A-C's Graduate Training Course.

Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin

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RAYTHEON MANUFACTURING CO.
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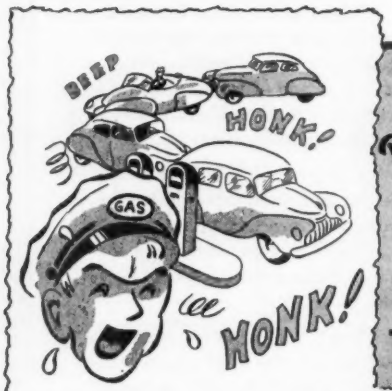
Raytheon has especially designed and produced millions of special purpose tubes for non-entertainment applications such as in *Hearing Aids, Aircraft Control, Guided Missiles* and *Long-Life Industrial Apparatus*, so could doubtless help you with your special tube requirements.

Over half a million Subminiature Tubes are carried in stock.

Sales engineering service is maintained in Newton, Chicago, Los Angeles and London.



DRIBBLE DRIBBLE
TOIL and TROUBLE

(*With Apologies to Shakespeare*)

"Dribble filling" of automobile gasoline tanks can be a prime source of wasted time and lost tempers. That's where VENTALARM® Signal pays off dividends in efficiency and economy.

Installed on any standard automobile tank, the VENTALARM Fill Signal permits fueling at full pumping speeds *without blow-back;* provides instant, positive warning when the tank is properly filled.

For fast-filling, non-spilling efficiency — for complete automotive convenience — specify VENTALARM installation when you order new vehicles.

SCULLY SIGNAL COMPANY
Cambridge 41, Massachusetts

VENTALARM
GAS TANK FILL SIGNAL

FOOD, FUEL, AND FAITH

(*Continued from page 266*)

We entered the war with a good navy, which however was largely put out of commission in the first day at Pearl Harbor. We ended the war with a navy whose power exceeded the combined navies of all other nations of the world. We entered the war with a pitifully weak air force, whose few planes were obsolete from the day the war began. We took President Roosevelt's goal of 50,000 new planes a year as a happy dream or a figure of speech, but we built them and many more, and ended the war with the world's greatest air force — great both in equipment and men. We entered the war with but a skeleton army, so lacking in equipment that wooden guns had to serve for the first field maneuvers. I remember an estimate, in the days after the outbreak of the war in Europe, that it would take four years for us to manufacture basic equipment for an army of 1,000,000 men. I remember when a Signal Corps officer showed me a field communication switchboard and said sadly: "This is the only one our army possesses, and it is ten years out of date." But we created a ground army of 6,000,000 men, well trained and magnificently equipped, which, with our allies, completely defeated the most war-minded nations who had spent years in preparation for world conquest.

While these military forces were being trained and equipped, we built a merchant marine at incredible speed, and once more became a first-rate ocean carrier.

While doing all this, we also supplied enormous amounts of food and of military supplies to our allies. And, in spite of war restrictions on gasoline, food, textiles, and other commodities, we maintained throughout the war a standard of living superior to that which any other country has ever maintained even in peacetime.

Not only in mass production, but also in designing and producing new instrumentalities of war, was the record extraordinary. Perhaps these new technological developments were the most outstanding of all our achievements: amphibious landing craft, new types of radar, antisubmarine devices, antiaircraft fire controls, synthetic rubber plants, and a host of other items were the products of the great mobilized effort of our research scientists, development engineers, and production industries. And to cap the climax, the atomic bomb, which even the top German scientists declared to their High Command was an achievement impossible for any nation in wartime. Amid all the other activities required by a desperate two-front war, to have developed the atomic bomb and the basis for atomic energy, with an expenditure of $2,000,000,000

(*Continued on page 290*)

BIG GAME HUNTING
NORTHWESTERN WYOMING
Elk — Deer — Moose — Bear
Mountain Sheep

Early arrangements necessary. Moose and sheep licenses must be applied for before July 1st.

SUMMER ACCOMMODATIONS FOR FAMILIES
Trout Fishing *Pack Trips*

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THE TRIAL IS NEVER OVER

GOOD-WILL is the disposition of the customer to return to the place where he has been served well—

U. S. Supreme Court.

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We do not believe that any advertising copy man could have penned a neater and more trenchant definition than this decision of the Supreme Court.

It happens also to be the verdict which our customers have reached regarding their relations with us.

Your specific problems in technical reproduction work from the lowly blue print to the complicated offset printing of an engineering manual, will find their happy solution with us.

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The
RUMFORD PRESS
CONCORD
NEW HAMPSHIRE

WHERE
Printing
IS STILL A CRAFT

14 STANDARD SIZES OF UNIVERSAL JOINTS
FROM 4" TO 3/8" DIAMETER

offering modern industry a real advantage in having universal joints, of the highest quality, available for immediate shipment.

This wide range of sizes — with either solid or bored hubs — fits most universal joint needs — from instrument controls to heavy duty steel mill applications.

Curtis makes universal joints exclusively and their 25 years experience is yours to command. Special machining for specific applications is done before assembly — saving money and insuring accuracy.

Send us your universal joint problems, indicating speed, angle of operation and torque load, with blueprints if possible. There is a Curtis Universal Joint immediately available to you — whether for a heavy duty 4" installation or a high-speed light duty job.

WRITE DEPT. B-5

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.

FOOD, FUEL, AND FAITH

(*Continued from page 288*)

and the work of 5,000 scientists and 65,000 others, is indeed an achievement.

I have mentioned all these accomplishments, not for the purpose of boasting about the United States, but in order to emphasize just one point: the test of war proved that our nation possesses great strength; that there are enormous reserves of power in its people and in its operations. Should we not therefore be confident of the essential soundness of what we call "the American way of life"? Taking the broader view to include the truly democratic countries generally — and without shutting our eyes to the problems which continually arise — have we not good reason for faith in democracy and free enterprise?

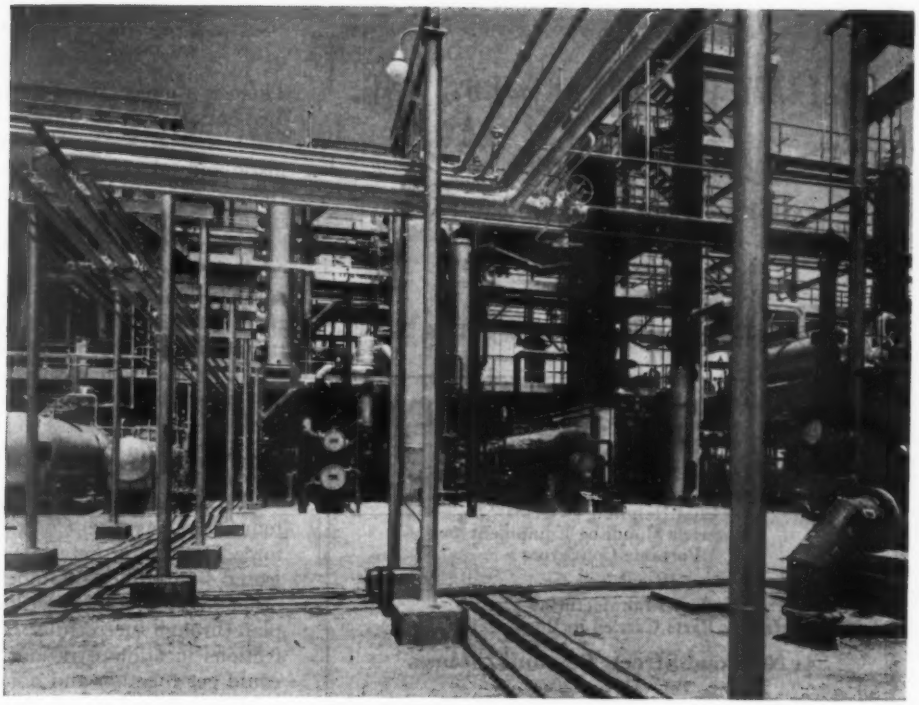
At a reunion of Alumni of the Stevens Institute of Technology, during the last week of January, President Wriston of Brown University gave a stirring address on the subject "Real Fears and Vague Hopes." In it he listed item after item to illustrate our present lack of national self-confidence and our almost emotional panic. He drew the conclusion that our great damage from World War II was not loss of goods or mountainous war debt, or even the distressing loss of life, sad as these are. He argued that the most serious damage inflicted on us by the war is the emotional unbalance, amounting almost to hysteria, which is our war aftermath. Consider only two of its manifestations.

First is the fear of Communism, as evidenced by the tendency to regard as a dangerous person, or at least a suspicious one, any one who ever belonged to the American Student Union, or who reads *PM*, or who is on the mailing list of the Council of Soviet-American Friendship. Another evidence is the pending Barnes Bill in this Commonwealth which would impose a jail sentence or a $10,000 fine on me, and possibly on other administrative officers and members of the Executive Committee of M.I.T., or on any administrative officer of any school in Massachusetts, if any instructor or janitor or stenographer employed by us should ever express approval of Communist doctrines. Such doctrines include, I am told, support of the United Nations and equality of treatment of people of all races, colors, or creeds, along with other doctrines which most of us deem much less laudable.

Let me make it clear that I do not approve of Communism. Its record is not good. Its current practices are subversive to our democratic way of life and to the social system which has made the United States a great and prosperous nation. In view of the practices and some of the doctrines of the Communist party, I believe that their members or followers should not hold responsible public office in our government. But I also believe that our fear of Communism is going to absurd limits, for the following reason.

There is a general principle of nature called "the survival of the fittest." Communism and democracy are at opposite extremes of social doctrine. Which of the two is fittest to survive? If we have real faith in democracy and free enterprise, if we are not blind to the evidence which I have quoted as to the strength of our nation, we should not give the appearance of fear of Communist competition; we should not go to some of the extremes which seem to me only to indicate lack of faith in our own system.

(*Continued on page 292*)



CLEANLINED . . . for operation . . . for maintenance

Petroleum refinery, chemical or petro-chemical plant. . . . After the process engineering—which must be correct for desired product yields and quality—comes the all-important matter of design engineering. For it vitally affects the cost of operation and maintenance.

It is here that cleanlined plant planning and foresighted equipment locating reward the owner—both while operation is in progress and when inspections, cleanouts or replacements are in order.

Badger engineering takes these long-range factors into consideration in every project this widely experienced organization undertakes.

Note the orderly layout of the Badger-built plant shown above . . . the time and labor saving accessibility of all equipment.

These reflect *expertness in execution* that is evident in all stages of Badger engineering and construction service—from process design to final operating unit.

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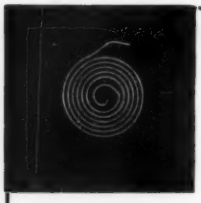
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FOOD, FUEL, AND FAITH

(*Continued from page 290*)

There is a great difference between wise precaution and firm action, which are necessary to prevent disturbance and loss, and the hysterical tendency to label as communistic and subversive any beliefs which are liberal, unorthodox, or perhaps too idealistic for realistic application in the present day world.

A second example of our lack of faith is found in some of the current efforts to whittle down, and perhaps even sabotage, the Marshall Plan for European Recovery. This plan is a magnificent conception, based upon both humanitarian and properly selfish interests. On the one hand, we wish to help those in distress. On the other hand we know that we cannot long remain prosperous, or even safe, with the rest of the industrial world poverty-stricken and in political turmoil. A stable America requires a stabilized Europe.

The Marshall Plan was not conceived as an anti-Soviet move. It was the Communist-dominated bloc which forced that interpretation on it, for, until this bloc rejected it, its offer was open to them just as to all the others. But now this is still another reason for seeing the plan through successfully. To be sure there will be imperfections in administration; no diverse group of nations could get together and operate without giving cause for criticism. But the basic thing is that they have agreed to get together and try to work together if we will help.

But now certain elements in the Congress and elsewhere are trying to whittle off here and again there, and to impose restrictions so that our own economy will be protected. They argue that our economy cannot stand the strain. I feel like quoting from the Bible: "O ye of little faith." In funds and materials what is called for is but a small part of what the war cost us over and beyond our domestic needs. The total funds involved equal only a third of what we spend on tobacco, jewelry, alcohol, cosmetics, and amusements. And the Plan is to operate for only a few years. The stakes are high and the probable returns on the investment are very great. Failure to act promptly and adequately, and even generously, would seem to me to be another evidence of lack of faith in our own strength, and very shortsighted.

My conclusion, therefore, from all these things which I have tried to say to you, is that our country has more than food and fuel; it has the basic vitality and ideology to justify our firm faith in its future. Our one danger lies in succumbing to doubts which can undermine this faith; doubts which are like molehills magnified in our minds into mountains as we worry about the inevitable problems

(*Concluded on page 294*)

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FOOD, FUEL, AND FAITH

(*Concluded from page 292*)

arising from the complexity of life in this postwar period of reconstruction. My hope is that the sons of M.I.T. will be distinguished for their effective faith in the basic principles and institutions which have made our country the "Sweet land of liberty."

And now for the more personal application to you individually of my text: "Food, Fuel, and Faith." Whether you are citizens of the United States or, as many of you are, citizens of some sister nation, you are graduating into a world where technology is needed and valued as never before. Whether in science or engineering or architecture, whether in business or teaching or professional practice, you should face your future with confidence.

I am tempted to say that you can face the world with the same confidence as was felt by the Christian gentleman who entered a poker game with four aces up his sleeve. Your first ace is the fact that you were picked to enter M.I.T. against heavy competition. Your second ace is the best education which could be given you by the best technological institution in the world. Your third ace is the continued interest and help which this institution will give you as Alumni. Your fourth ace is the world's need for men of your type of training.

So I do not worry about your ability to find food and fuel. You have every reason also to have faith in a future of satisfying achievement. My parting message to you as students and my first message to you as Alumni is, therefore, the assurance that the Corporation and Faculty of M.I.T. have faith in you.

I can think of no more appropriate way of ending this address than by quoting the text of another baccalaureate address to one of our graduating classes by Senator Saltonstall, then Governor of Massachusetts. This text expresses so well many of the things I have tried to say to you today, and it is well worth remembering from time to time as a recipe for a good life: "Look forward, not back; look upward, not down; and lend a hand."

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Cambridge
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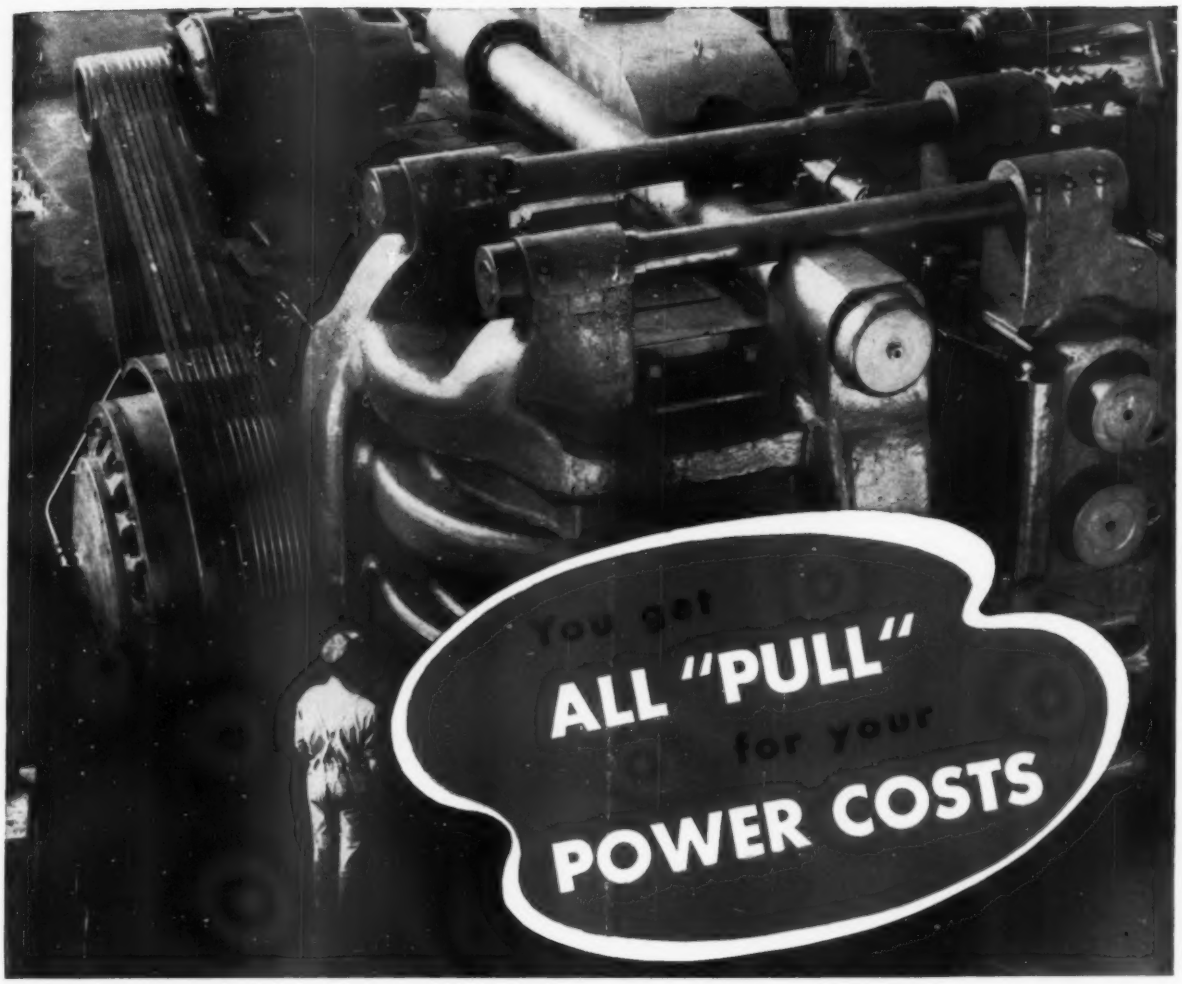
ITEMS OF OUTGO	*At Dec. 31, 1947*	*At Dec. 31 1946*	*Net changes during 1947*
Number of men receiving loans	2708	2647	+61
Total Amount Loaned	$1,956,189.75	$1,918,740.75	+$37,449.00
Average per capita loan	$722.37	$724.91	−$2.54
ITEMS OF INCOME			
Number of men whose indebtedness has been completely discharged	2015	1922	+93
Principal repayments *in advance*	$558,648.86	$540,875.27	+$17,773.59
Other principal repayments	$1,032,494.40	$979,983.79	+$52,510.61
Total principal repayments	$1,591,143.26	$1,520,859.06	+$70,284.20
Total principal matured, considering "advance repayments" as matured when paid	$1,623,724.35	$1,556,277.56	+$67,446.79
Collection Ratio, *i.e.* percentage of total maturities paid	**97.9%**	**97.8%**	**+00.1%**
Matured principal in arrears	$26,613.28	$29,792.19	−$3,178.91
Actual "written off" accounts	$5,967.81	$5,626.31	+$341.50
Total maturities unpaid	$32,581.09	$35,418.50	−$2,837.41
Interest received	$215,835.59	$208,239.87	+$7,595.72
NOTES OUTSTANDING	$359,078.68	$392,255.38	−$33,176.70



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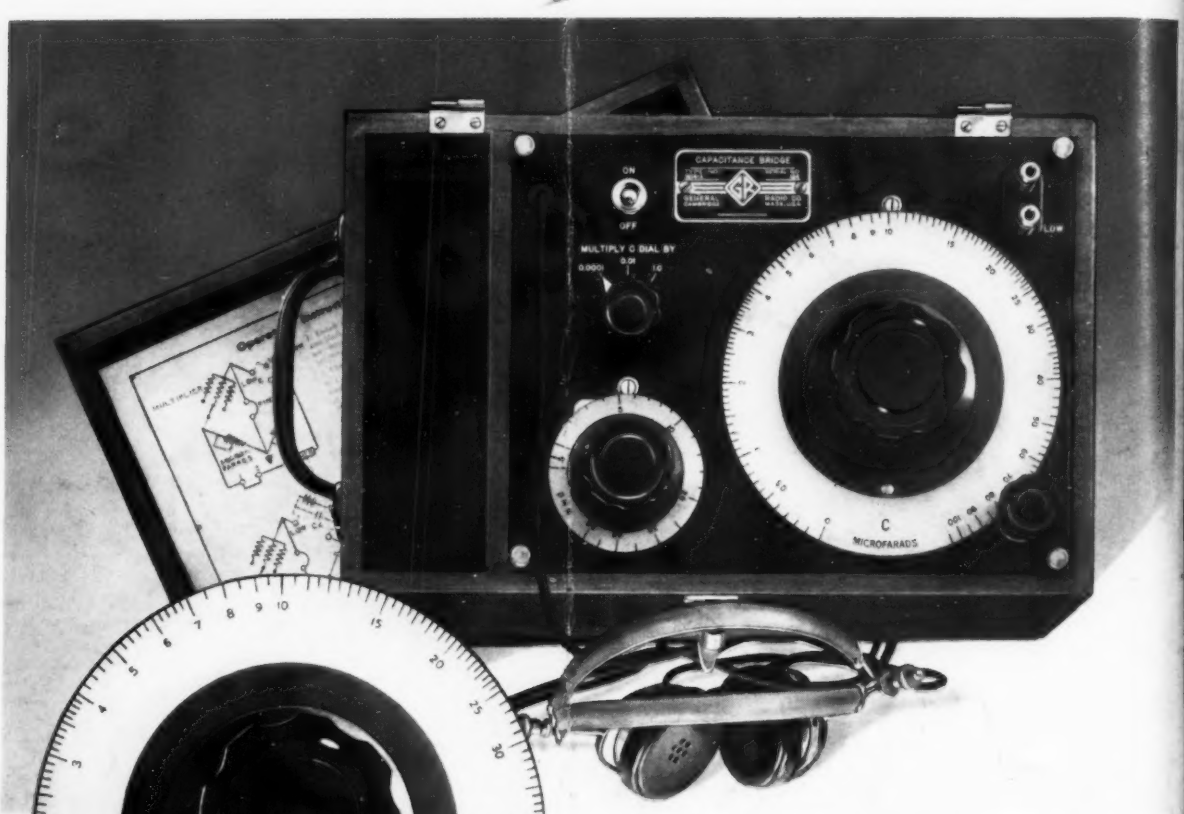

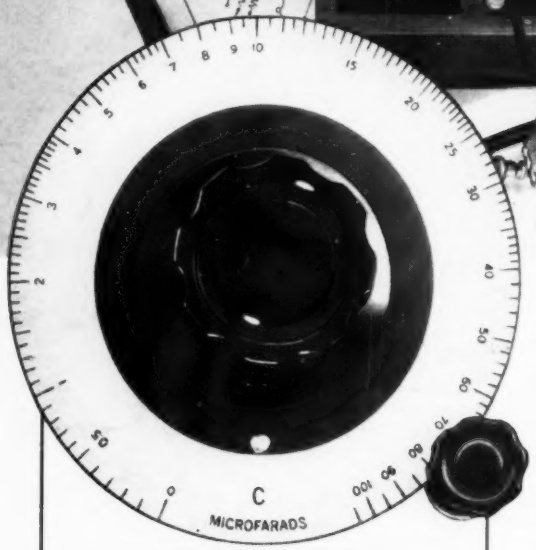

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